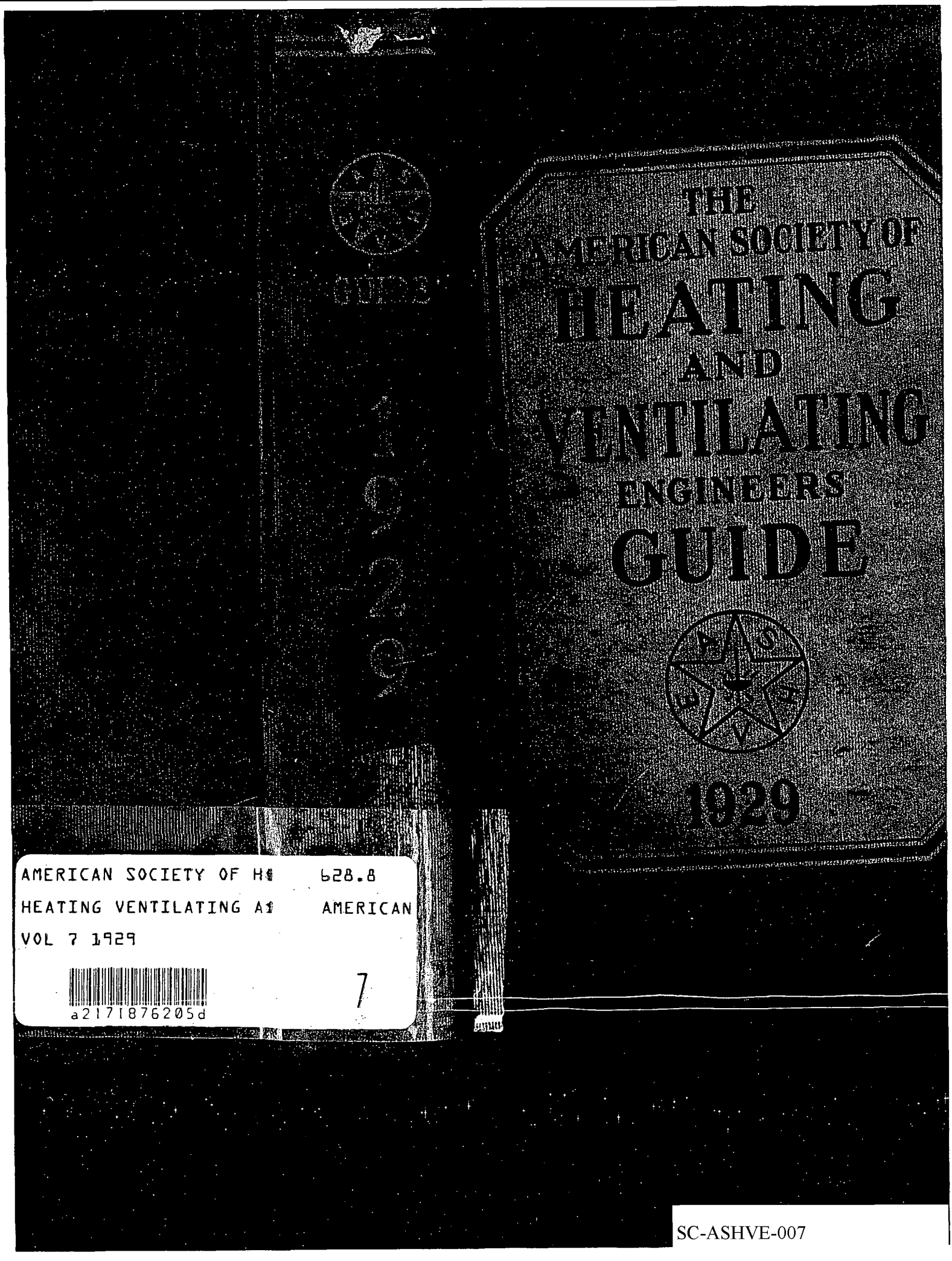


AMERICAN SOCIETY OF H 628.8
HEATING VENTILATING A AMERICAN
VOL 7 1929
a2171876205d
7

SC-ASHVE-007

ST. LOUIS PUBLIC LIBRARY

American Society of Heating and Ventilating Engineers
Heating ventilating air conditioning guide.
VOL 7 1929

St
628.8
AMERICAN

21718 76205

ST. LOUIS PUBLIC LIBRARY 1893 ST. LOUIS, MO.

No. 1011989

This Book Shall Not Be Taken From The Library.

AMERICAN SOCIETY *of* HEATING *and* VENTILATING ENGINEERS GUIDE

1929

CONTAINING DESIGN AND SPECIFICATION DATA USEFUL IN THE PLANNING AND CONSTRUCTION OF MODERN HEATING AND VENTILATING INSTALLATIONS—PREPARED FROM THE SOCIETY'S TRANSACTIONS—INVESTIGATIONS OF ITS RESEARCH LABORATORY—AND THE PRACTICE OF ITS MEMBERS

TOGETHER WITH A

MANUFACTURERS' CATALOG DATA SECTION CONTAINING ESSENTIAL AND RELIABLE FACTS CONCERNING MODERN EQUIPMENT

AND A

CONSULTING SERVICE SECTION FOR ENGINEERS

ALSO

THE ROLL OF MEMBERSHIP OF THE SOCIETY

WITH

COMPLETE INDEX OF TECHNICAL AND CATALOG DATA

Vol. 7

Second Printing

$5.00 PER VOLUME

1011989

PUBLISHED ANNUALLY BY

AMERICAN SOCIETY *of* HEATING *and* VENTILATING ENGINEERS

29 WEST 39TH STREET ∴ NEW YORK

Ref. 628.8

Copyright, 1928
by
American Society of Heating and Ventilating Engineers
and by it
Dedicated
To the Advancement of
The Profession
and
Its Allied Industries

Second Printing
June, 1929

Printed and Bound by
The Horn-Shafer Company
Baltimore :-: Maryland

Contents

		Page
Index to Technical Data Section		iv-xiii
Code of Ethics		xiv
	Heating Section	1–356
Chapter I.	Heat Losses from Buildings	3
Chapter II.	Radiators and Heaters	65
Chapter III.	Steam Heating Systems and Piping	79
Chapter IV.	Hot Water Heating Systems and Piping	113
Chapter V.	Heating Boilers	133
Chapter VI.	Chimneys	147
Chapter VII.	Mechanical Draft	159
Chapter VIII.	Gravity Warm-Air Furnace Heating	167
Chapter IX.	Fan Furnace Heating	189
Chapter X.	Unit Systems for Heating and Air Conditioning	197
Chapter XI.	Central Heating Systems	203
Chapter XII.	Greenhouse Heating Systems	215
Chapter XIII.	Domestic and Industrial Oil Burning	219
Chapter XIV.	Heating with Gas	233
Chapter XV.	Heat Insulation for Pipes and Surfaces	247
Chapter XVI.	Automatic Heat Control	259
Chapter XVII.	Heat Exchangers for Water and Oil	277
Chapter XVIII.	Pumps and Traps for Heating and Ventilating Equipment	287
Chapter XIX.	Laundry, Kitchen and Hospital Equipment and Piping Systems	311
Chapter XX.	Water Supply Systems and Piping for Buildings	335
Chapter XXI.	Pipe and Fittings	343
Chapter XXII.	Design and Operating Data for Mechanical Equipment of Federal Buildings under control of U. S. Treasury Dept.	349
	Ventilation Section	357
Chapter XXIII.	Modern Standards of Ventilation and Measurements of Air Quality and Quantity	357
Chapter XXIV.	Systems of Ventilation	379
Chapter XXV.	Air Conditioning and Cooling	393
Chapter XXVI.	Selection of Fans for Heating, Ventilation, Drying and Conveying	407
Chapter XXVII.	Motive Power and Controls for Fans	417
Chapter XXVIII.	Air Duct Design and Construction	421
Chapter XXIX.	Air Cleaners	433
Chapter XXX.	Ozone in Ventilation	441
Chapter XXXI.	Methods of Drying	449
Chapter XXXII.	Dust, Exhaust, Collecting Systems	461
Chapter XXXIII.	Natural Ventilation	471
Chapter XXXIV.	Codes and Standards of the A. S. H. & V. E.	483
	Consulting Service Section	489–492
	Catalog Data Section	495–818
Manufacturers' Catalog Data		493
Index to Modern Equipment		819
Index to Advertisers		841
	Roll of Membership	1–58
Officers and Council		2
Officers of Local Chapters		4
Alphabetical List		5
Summary of Membership		45
Geographical List		46
Past Officers		55

INDEX TO

TECHNICAL DATA SECTION

(Pages 1–488)

CROSS REFERENCE TO SUBJECTS IN CHAPTERS I-XXXIV ALPHABETICALLY LISTED

A

Page

Air
amount of 394
and ozone mixtures 445
atomizing in oil burning 228
capacities of vacuum pumps 295
changes in ventilation 358
circulation of currents 454
circulation of, in fan furnace heating 189
circulation of, greenhouse heating 218
cleaning of 401
combustion of, in gas heating 236
combustion of, in oil burners 229, 230
conditioning and cooling 393
conditioning, definition of 393
conditioning for human comfort 374
conditioning units 200
control of, in burning coke 143
controlling effect on 401
cooling 360
current dryers 451
definition of 394
determination of, leakage 48, 49
distribution of heated 167
duct velocities for forced draft 163, 164
flow, testing 364
flow of, in units 201
friction of, in pipes 424
functions of, in ventilation 359
humidifying of 401
measurements, volumetric 364
motion of 359
movement of 366, 393
purity 359
qualities required for ventilation 358
quantity of 381
quantity required in hospitals, hotels, theaters, schools 394
recirculating 174, 175
recirculation of, in ventilation 361
relative humidity of 394
requirements in gas heating 237
standard velocities of 423
steam requirements for heating and humidifying 435
supply for ventilation 358
supply to warm-air furnace 168
temperature 359
temperature at registers 169
temperature of incoming, in ventilation 360
test for vacuum pumps 296
traps 309
velocity 463
volume required 456
Air chart
description of synthetic 484
Air cleaners
rating of 440
types of 433
Air conditioning
advantages and disadvantages of 202
for human comfort 374
types of units 201
use of in refrigeration 397
use in industries 201, 202
Air cooling
methods of 374, 375, 376, 377
Air duct
design and construction of 421
Air filters
dry 436
essential requirements of 439
viscous 437
Air motion
effect on comfort 436
temperature, humidity and 369
Air washers
automatic control of 367
humidity control 262
types of 262
Anemometers 433
Anthracite
heat value 364
sizes of 142
Apartment houses 142, 143
hot water requirements
sizes of water supply mains and meters 341
water supply risers 338
Applications of natural ventilation 337
Atmosphere 482
humid in greenhouses
Atmospheric conditions 217
Automatic heat control 378
Automatic control 259, 260
applications of 261
arrangement of installation 266, 267, 268, 269
central station practice 269
control devices 223
cost of refrigeration 270

Page

direct-indirect radiators 263
double thermostat 271
fan furnace heating 190
fan radiator units 263
for tempering heaters 261
fresh air intakes, in unit systems 263
gas burning appliances 266
gas heating 235
heat requirements 266
hot water radiators 264
humidity control 262
lag of instruments 275
laundry machines 269
oil burner control 265, 266
performance data on temperature regulators 275, 276
position of air washers 262
principles of operation 274
problems of, in heating by direct radiation 276
refrigerating units 269
room temperatures 262
service hot water heater 265
temperature change 274
temperature fluctuations in plenum systems 276
thermostatic equipment for buildings 271
unit type thermostats 270
variation in room temperature 273, 275
warm air heating systems 265

B

Bacteria 363
Bake shop
equipment 322
fuel for 322
location 322
oven, capacity for 322
Body heat
loss of 367
Boilers
application of oil, to coal burning boilers 224
care of heating 146
cast iron 138
check on installation 140
chimneys for 157
cleaning flues 146
coal fired, rating 136
complaints and causes 140, 141
drip connection 139
fire-tube 138
fuel bed 145
gas 234
heating 133
heating in federal buildings 351
installing and preparing 139
method of cleaning 139
output 134, 135, 146
pick-up load 146
piping 139
protection of 140
purpose of heating 133
rate of combustion 135
rating of gas fired 137
ratings of, for oil fuel 137
rules for operating with various fuels 141
secondary air 141, 142
sectional 138
section of heating 133, 134
size, rating and capacity of 137
smoke breeching and chimney connections 140
specification 133, 134
stoking 145
types of 137
used with oil heating equipment 224
water in 146
water-tube 138
Burner controls
automatic 223

C

Cafeteria restaurant service 322, 323
Calculations
for heat transmission losses 46, 47
Capacities
roof ventilators 478
Central heating systems 203
control 269
Chart
psychrometric, for moving air 369, 370, 372
psychrometric, for still air 368, 378
psychrometric for still and moving air 375
Chimneys
amount of air required for 150
area of flue lining for warm air furnaces 158
available draft 149, 150
back draft diverted 156
classes of 151
construction of 156, 157
construction of walls 157
correction factor for 149, 150
correction factors for altitude 155
design 226
draft 224
draft measurement 147
flue connections 156
flue linings 157
for gas appliances 155
forced draft 147
for gas heating 237
functions of 147
head produced, draft 151, 152
height of 157
horsepower rating 150, 151
induced draft 147
loss due to friction of gases 149
loss due to velocity 149
loss of draft in breeching 149, 150
loss of draft through boilers 150
loss of draft through fuel bed 155
low-pressure heating plant 151
minimum cross-sectional areas of round 156
natural and mechanical draft 147
products of combustion 156
provisions for heating boilers and furnaces 157
quantity of gases 150
requirements for oil fuels 152, 153, 155
sizes 152, 153, 154
smoke-pipe connection 158
smoke test 158
theoretical draft 147, 148, 150
Circulation
booster fans equipment 188
forced or booster 188
of air currents 454
Cleaning units 399
CO_2 determinations 363
Coal
caking coal 144
characteristics of bituminous 144
heat value of bituminous 144
lignite 144
method of firing bituminous 145
non-caking 145
semi-bituminous 144
types of bituminous 144
Coefficients
definition of heat transmission 7
heat transmission 7, 10, 13, 21, 47
tests for determination of transmission 9, 10
transmission 9
transmission by computation 10, 13, 19, 21
Coke
firing 143
sizes of 143
weight of 144
Comfort charts
use of 370, 371
Comfort line
equal 372
Comfort zone 368
Computations, heat loss 372
Conditions
climatic 4, 5
Convection
heat radiation and 8, 9
Condensation
rate of in radiator 10, 11
75, 76

	Page
Connections; typical for	
blast heaters	111
boilers	85
ceiling radiators	111
concealed radiators	110
fan connections	380
hot water heater	112
hot water heating systems	121
indirect radiators	110
pipe coils	109
radiators	110
risers	109
steam heating systems	81, 82, 83, 84
steam mains and branches	108
tanks	112
unit heaters	111
Conditioning	
air, units	200
Continuous type of roof ventilator	480
Codes and standards of A. S. H. & V. E.	483
Code	
standard, for installation of warm air furnaces	181, 188
Cold coils and sprays	399
Collecting systems	
classification of	461
Collectors	468
Compartment dryers	451
Condensation pumps	
capacity	291, 293
capacity of centrifugal pumps	289
condensate	291
piston speed	289, 290
types of	289
volumetric capacity of receivers	289
volumetric displacement rate	289, 291
Conductivities	
insulation	251, 252, 253
of building materials	12, 18
Conduits	
filler type	213
heating	211, 212
insulated tile type	213
laying out of heating	211, 212
sectional insulation type	213, 214
Connections	
service from high pressure and low pressure system	203, 206, 208, 212
Construction of dryer	456
Continuous dryers	451
Control	
automatic gas heating	235
Control	
of drying operation	456
of ventilation	481
time limit	203
Conveyor	
pipes	469
Cooling	
air	360
problem of air	360
Cylinder dryers	450

D

Dairy stable ventilation	480
Data	
heat transmission	13
on isolated electric plants	354, 355
on kitchen, laundry and hospital equipment	311
Definitions	
boiler capacity	136
boiler ratings	136
boiler size	136
branch risers	80
built in heaters	66
cabinet heaters	66
capacity	136
concealed radiators	66
dehumidifying	395
dew-point	394
direct radiators	66
down-feed system	80
effective temperature	357
fumes	433
gravity warm-air furnace heating	167
heat transmission coefficients	7
indirect radiator	66
one pipe gravity system	80
pump fittings	303
pump terms	304, 305
recessed radiator	66
return mains	80
supply mains	80
system	80
two pipe system	81
types of pumps	303
up-feed system	80
vacuum system	80
vapor system	80
Design	
chimney	226
collecting hoods	468
domestic fuel oils	220
domestic hot water supply	224
Domestic oil heating	
selection of unit for	219
Double thermostatic control	270
Draft	
boilers	147
forced	159
friction losses	147
gas heating equipment	147, 237
induced	159
in industrial oil burning	230, 231
mechanical	159, 456
natural	455
Dryers	
agitator	450
air-current	451
arrangement of	456
arrangement and construction of	456
Drying	
artificial	449
compartment	451
construction of	456
continuous and intermittent	451
cylinder	450
film	450
spray	450
tumbler	451
types of	450
vacuum	450
Drying	
artificial	449
control of	456
definition of	449
high temperature	452
low temperature	453
methods of	449
natural	449
Ducts	
design of, in fan furnace heating	191, 192
recirculating air supply, and grilles	174, 175
return	175
Duct temperatures	
measuring of, in ventilation	362
Dumping grates	
ash accumulation	160
Dust	461
atmospheric	363
Dusts	
defined	433
Dust removal	
efficiency in	439

E

Effective temperature	357, 359
Elbows	
friction in	340, 427
Electric motors	
controllers for	419
Electrical current	
kinds of	419
Elevators in federal buildings	351
Equipment	
booster fans	188
Exhaust and collecting systems	461
Exhaust fan	
selection of	467
Exhaust systems	431
important requirements of	461
maintenance of	470
types of	461
Expansion	
pipe line in central heating systems	205

F

Fan blast duct design	190
Fan furnace heating	
circulation of air	189
design of ducts	191, 192
design of fan furnaces	189
direct transmission heaters	193
efficiency of heating surface	193
free area and resistance	193
heater arrangement	189
heaters designed for	189
selecting the heater	193, 194
Fan	
arrangement of drive	415
Fan application	
methods of	380
Fans	
booster, equipment	188
capacities and dimensions of forced draft	165
centrifugal	407, 417
characteristic curves of	407
characteristics of	407
classes of	407
designation of	415
disc and propeller	407, 417
drying and conveying	413
electric motors for	418
general suggestions on	415
heating	407
mechanical draft	162
motive power for	417
multiblade	411
other power sources for	420
position of	189
selection of	407
speed control of	418
types of	407
ventilation	412
Fan system for heating and ventilating	380
Federal buildings	
conduit and wiring	351
conduit and wiring illumination	351
cost of heating	354
cost of maintenance and operation	354
costs of operating supplies for	354
cost of repairs in	354
costs of repairs to	355
dining rooms of marine hospitals	353
drinking water	350
electric plants, data on isolated	354, 355
elevators	351
employees	353
equipment of heating boilers	351
fire hose	349
heating equipment of	351
heaters, hot water	350
heating requirements	356
kitchen equipment of marine hospitals	351, 352, 353
machinery charges and depreciation for	356
mechanical equipment for marine hospitals	352
mechanical equipment of	350
operating data on	353
plumbing equipment for smaller	349
sewers	350
size of water service	350
steam, amount used	354
storage tanks	350
Filters	
air	436
unit viscous	438
viscous air	436
Fittings	
definitions of pumps	303
pipe	348
Flow	
cold water	335, 336
steam in pipes	86
Flues	
cleaning boiler	146
Forced draft	
air duct velocities for	163, 164
amount of air for	163
arrangement	166
control of motors	166
direct method	162
fan capacities and dimensions	164
firing condition	163
motor driven blowers	166
rates for fuel burning	163
Formulae	
coefficient heat transmission	21
water supply	340
Friction	
drop in pipes	466
in elbows	427
losses in pipes	423
Fuel	
coals	190
fuel oil specifications	219, 220
gas	191
liquid	219
oil	191
Fumes	
definition of	433
Furnace	
air supply to warm-air	168
capacity of	174, 177
chimneys for	157
combustion volume in industrial oil burning	230
construction of gas burning warm air	235
designing, a heating system	169
design of fan	189
grate area	176, 177
gravity warm-air heating	167
method of check	178, 179
performance curves	174, 177
size of	176
standard code for installation of warm-air	181–188
types of warm-air, heating plants	168
Gages and manometers	365

G

Gas	
boilers	234
chimneys for burning appliances	155
consumption in heating	239
combustion of in gas heating	236
efficiencies	238
heat values of	237
heating	233
requirements for heating large buildings	245
Gases	
in bituminous coal fires	145
volume of flue	162
Gas heating	
automatic control	235
bunsen flame	234
coal burning applicance	234
combustion of gas	236
construction of warm-air furnaces	235
conversions	233, 234
costs	239
cross connecting coal and gas boilers	242
fuel utilization	233
installation and control of boilers and appliances	235
large unit boilers	233
luminous flame	234
principle of design	235
radiant heaters	236
reduced rates	233
space heaters	236
venting devices	235
Grates	
dumping	160
shaking	160
stationary	160

Page

Greenhouse heating
heating apparatus 215
heating coils 216
hot water radiation 216, 217
humid atmosphere 217
pipe expansion 215
radiation 215, 216
structure 215
temperatures 215, 216
Gravity systems
for hot water supply 342
hot water heating 121
one pipe steam 80
two pipe steam 81
warm-air furnace 167
Grilles
free area of recirculating 175
location of 175

H

Heat
allowance for infiltration 48, 53, 54, 55
area of losses 46
automatic heat 259, 260
balance of gas burning equipment 238
calculating losses 3, 4
calculating for, transmission losses 46, 47
calculation of, emission of indirect radiators 71, 72
capacity of leader pipe 169
coefficient of radiator 113, 114
conversion factors for emission 67, 68, 69, 70
dissipated from human body 373
effect of 77, 78
effect of humidity on 75
emission of radiator 65, 67
from occupants, lights, etc 360
heat content of oils 219, 221
insulation for pipes and surfaces 247
latent 373
loss by evaporation 377
loss computations 4, 5
loss for average man 376
loss in money and fuel 247, 249
loss per person 376
loss per unit area from flat surfaces 247
losses from bare fittings 252, 258
losses from buildings 3, 169
nicholls meter 14
pipe and surface losses 247
radiant 449
radiation and convection 10, 11
required for buildings 63
requirements 266
sensible 373
sources 60, 61
transfer coefficient 280, 281
transfer in hot water heating systems 113
transmission coefficients 7, 10, 13, 21, 47
transmission data 13
value of gas 237, 238
Heaters
built-in or concealed 66
cabinet 66
convection type of, space 236
direct *transmission* 193
extended surface 69
for fan furnace heating 189
indirect 66
industrial unit 197
kinds of heat emitting units 65, 66
luminous flame reflector 236
operation of 71
propeller fan type unit 199
radiant 236
rating of 66, 71
recirculating unit 198, 199
selection of 73, 115
space 236
suspended unit 199
useful heat output of 67
Heat exchangers
average temperature difference 283, 280
coefficient of heat transfer 280, 281
design of 285, 286
economics in design of 286

Page

heat conductivity for liquids 285
heat transfer 279, 280, 284, 285
heat transmission 277
logarithmic mean temperature difference 281, 283
resistance of oil water film 282
variation of 284, 285
velocity of fluid 277, 278
viscosity of oil 282, 283
viscosity of water 282, 283
Heating
air requirements for gas 237
amount of radiation 65, 113, 242
apparatus for greenhouse heating 215
automatic control of humidity in fan furnace 190
automatic temperature control 190
boilers 133
central systems 203
chimneys 147
conduits 211
control of installations 243, 245
convection type of space heaters 236
costs in federal buildings 354
costs of gas heating 243
curve of gas consumption 239
degree-days in gas 241
description of piping systems for steam 80
design of gravity circulating warm air systems 167
design problems in steam systems 79, 97
determination of pipe sizes 87, 115
determining pipe sizes for gravity hot water 128, 129
federal buildings 350
gas 233
gas efficiencies 238
gravity hot water 127
gravity warm-air furnace 167
heat balance of gas burning apparatus 238
hot water heating systems with gas 242
humidifying pans in fan furnace 190
one-pipe and two-pipe steam system 80, 81
Hot water systems
pipe sizes and connections for hot water 130
position of fan in furnace 189
ratings for gas appliances 238, 239
requirements 3
requirements for federal buildings 356
selection of boilers 133, 134
specifications for, systems 7
steam, pipe sizes 87
steam requirements for air 435
systems of warm-air 167
tunnels 214
two-pipe gravity, systems 82
use of air washers in fan furnace 190
vacuum pump, systems 85
vapor, systems 83
vapor vacuum system of 81
with air 167
zone of occupancy 67
Heating systems
application of automatic control to warm air 265
capacity of steam lines at various pitches 95
comparative *cost of hot water* 116
empirical rules for hot water 127
example of use of diagrams for hot water 115
forced circulation in hot water 119
friction heads in pipes and elbows in hot water 125, 126
high temperature drying 452
hot water 113
method of determining pipe sizes for hot water 122, 123, 125, 126, 127
pressure, air sealed or closed hot water 132
quantity of air for indirect 381
radiation for 65, 113
tank sizes for hot water 131, 132
temperature difference, hot water 113
Hoods
design of 468
Hospitals
air for ventilation 358
hot water requirements 342
water requirements for 342

Page

Hospital equipment
blanket and solution warmers 329
condenser exhaust 334
nursery equipment 331
piping for sterilizers 331
proportioning equipment 328
size of waste connections 332
sterilization 331
sterilizer data 333, 334
sterilizers, cost of operation of 327
sterilizers, rating of 327
sterilizers, selection of types of 327
sterilizers, water 328, 329
utility rooms 330
waste and vent systems 332, 334
Hotels
air for ventilation 358
hot water requirements 341
Human comfort
effect of relative humidity on 377
Humidifying
definition of 395
Humidity
control in fan furnace heating 190
effect of, on heat transmission 75
readings 363
relative 4
temperature, and air motion 367

I

Ignition systems for oil burners 222
Illumination in federal buildings 351
Indirect heating system
quantity of air to be circulated in 381
Induced draft
induced draft fan 166
where used 166
Industrial oil burning
air atomizing burners 228
air for combustion 229, 230
auxiliary apparatus 231
continuous circulation system 232
domestic and 219
draft 230, 231
furnace combustion volume 230
mechanical atomizing 228
oil meter 231
selection of 230
steam atomizing 228
strainers for 231
tanks for 231
Industrial uses of ozone 448
Infiltration
calculations for 59
determination of air leakage 48, 49
due to temperature difference 59
effect of storm sash on 58
heat allowance for 48, 55
through steel window 50, 55
through metal windows 50, 52
through walls 50, 53
through wood windows 50, 51, 55, 56
values in tables 55
weatherstripping and 56, 57
Insulation
chart to determine thickness of 255, 257
conductivities 251, 252, 253
determination of thickness 251
economic thickness of 253, 255, 258
economic thickness of underground 256
effect of air velocity on surface losses 254, 257
heat, for pipes and surfaces 247
purpose of, cold surfaces 251
Intermittent dryers 451

K

Kata—thermometer 366
Kitchen equipment
broiler 321
cereal cookers 319
coffee urns 319
cook's table 318
diet kitchens 322
dishwashing sink 321

Page

electric 324
fish refrigerator 320
gas connections for 326
grease traps for 326
ice chests 320
ice cream and sherbets 320
kettles, ovens and steamers, sizes of 318, 319
marine hospital 351, 352, 353
mixing machines 320
power requirements 324
proportioning equipment 317
range hood 317, 318
rated capacity of dish washing machines 321
return connections 326
sinks 319
sizes of ranges 317
steam and gas 317
steam pressures, used by 324
steam requirements for 324
steam supply connections 326
steam tables 319
types of dish washing machines 321
vegetable peelers 320
water connections 326

L

Latent heat 373
Laundry equipment
arrangement of equipment 316
equipment 312
flat work ironers 314
machines 311
pipe sizes and systems of piping 315
steam pressure required 315
systems, piping 315
tumbler dryers 314
typical layout 312, 313
washing machines 312
water softening 316
water, steam and power requirements 314, 315
Layout of kitchen for hospital 323
Layout of kitchen for hotel 325
Leaders
heat carrying capacity of pipe 169
sizes 169, 171
sizes of straight 170
temperature drop in 170, 171
Loss
areas of heat 46
calculating heat 3, 4
calculation of heat, from uninsulated surfaces 247
calculations for heat transmission 46, 47
heat 252, 253, 254, 255, 256
heat, computations 4, 5
heat, from bare fittings 252, 258
heat, from buildings 3, 169
heat, per unit area from flat surfaces 247
of heat in B.t.u. of bare pipe 247, 248
of heat in money and coal 247, 249
total body heat 367, 368
Low temperature drying 453
low voltage systems of oil burner control 223

M

Mains
return 80
sizes of hot water 342
sizes of water supply for apartment houses 338
sizing of 336
supply 80
transmission 87
Maintenance of exhaust system 470
Marine hospital dining rooms 353
Maximum water temperature in hot water heating systems 116, 117, 118
Mechanical draft 159, 456
burner 220
difference in pressure required 162, 163
firing 160
forced draft 159
grates for various fuels 159
induced draft 159
mechanical draft fans 162
over-feed stokers 161

	Page
selection of stoker	161
self-feeding stoker devices	161
shaking grates	160
sizes of fuels for dumping grates	160
stationary grates	160
stoker installations	161
types of stokers	161
under-feed stokers	161
use of	162
volume of flue gases	162
Mechanical exhaust	359
Mechanical ventilating systems, design of	359
Meter	
Nicholls' heat	14
oil	231
Methods of drying	449
Methods of fan application	380
Mixtures	
analysis of ozone-air	445
Moisture content	
calculations	452
explanation of	452
Moisture	
amount of in saturated air	454
removal of	456
Mechanical equipment of federal buildings	
amount of steam used	354
conduit and wiring	351
costs, boiler and engine room	356
cost of heating	354
cost of maintenance and operation	354
cost of operating supplies	354
cost of repairs	354, 355
direct steam radiation equivalent	356
drinking water	350
electric plants, data on isolated	354, 355
electric power and light, average and maximum demand for	356
elevators	351
employees	353
fire hose	349
fuel rooms	351
heating boilers	351
heating distribution	350
heating requirements	356
hot water heaters	350
illumination	351
machinery, charges and depreciation for	356
marine hospital dining rooms	353
marine hospital kitchen equipment	351, 352, 353
marine hospitals	352
maximum demand for steam	355
monthly consumption of steam	355
operating data on federal buildings	353
sewers	350
size of water service	350
storage tanks	350
ventilation, mechanical	351

N

Natural draft	455
Natural drying	449
Natural forces in ventilation	471
Natural ventilation	471
Natural ventilation	
application of	482
Nicholls' heat meter	14
Noise	
elimination of	361

O

Office buildings	
hot water requirements	341
Oil	
domestic fuel	220
traps	309
viscosity of	282, 283
Oil burner	
application of automatic control	265, 266
comparative cost figures	226, 227, 229
installation	224
natural draft	220
operation of burners	223
types and characteristics	220
Oil burning	
domestic and industrial	219
Openings	
ventilating	474
Operating data on federal buildings	353
Ozone	
chemical properties of	442
deodorizing of	443
determining proper concentration of	445
determining required capacity of	446
germicidal properties of	443
industrial uses of	448
in regard to cold storage	448
in ventilation	441
physical properties of	441
production of	444
water purification by	448
Ozone—air mixtures	
analysis of	445

P

Physiological effects	
of ventilation	366
Pipes	
amount of corrosion in	345
area of standard size	128
brass	347
capacity of	88
capacity of, at various pressures	90, 91
corrosion in	345, 347, 348
corrosion in copper and brass	347, 348
description of, size tables	89, 93, 95, 97
determining, sizes for gravity hot water heating	128, 129
determining the capacity of	98
effect of composition of iron on corrosion	345
factors for sizes of, in gravity hot water heating	129
fittings	348
flow of steam in	86
heat insulation for, and surfaces	247
method of determining sizes for hot water heating systems	122, 123, 125, 127
oxygen removal	345
per cent difference in capacity of	95
run of and expansion in greenhouse heating systems	215
scale on	343
scale, removal of	343
sizes and thicknesses of copper and brass	347
sizes of return in central heating systems	211, 207
standard dimensions of wrought	344, 346
uniformity of wrought	343
Pipe expansion	
determination of	205, 207
pipe sizes	209, 211
Pipe sizes	
central heating system	209, 211
cold water supply	335, 336
description of, tables	89, 93, 95, 96, 97
determination of, for steam heating	87
for air sealed or closed hot water heating systems	130
for hot water systems	341
for risers	335, 336
general data on tables	88, 89
length of run	87, 92
one-pipe gravity low pressure steam	96, 100
pressure drop	87
principle in determining	335
steam heating	87
two-pipe gravity low pressure steam	97, 101
two-pipe gravity vapor systems	99
two-pipe vapor heating systems	102, 103
unusual conditions in	88
vacuum pump systems	104, 105
Piping	
arrangement of	119, 121
arrangement of in greenhouse heating systems	218
boiler	139
brass	347
connections for unit heaters	202
copper and brass	348

	Page
description of, systems for steam heating	80
down-feed system of	80
friction in elbows	340
gravity system of	80
high-pressure systems for unit heaters	202
layout	130, 131
one-pipe gravity and vapor systems for unit heaters	202
pressure heads	124
service	87
systems	311
systems for hospital sterilizers	331
systems for laundry, kitchen and hospital equipment	311
two-pipe gravity connections for unit heaters	202
typical connections	108, 112
up-feed system of	80
vacuum system of	80
vacuum system return for unit heaters	202
vapor system of	80
Pitot tubes	364
code for the use of	483
Power requirements	
kitchen	324
Pressure	
total	335
water	339
Production of ozone	444
Proper humidity	378
Psychological factor in ventilation	361
Psychrometer	362
Psychrometric chart	372, 375
Public buildings	
unit systems for	389
Pumps	
air capacities of	295
air test for vacuum heating	296
automatic condensation and receivers	289
boiler feed piston speeds and efficiencies	287, 288
capacities of boiler feed	287
capacity of centrifugal	289
capacity of receiving tanks	295, 296
condensate of continuously operating	291
condensation	291, 293
definitions of fittings	303
definition of terms used	304, 305
freely vented air separating tank	299
horse power of motors	305
installation data	305
kinds of	287
lifts	301
location of receiving tank	295
piston speed of	290
piston speed of vacuum heating	295
size of steam driven vacuum heating	297
specifications of	302
standard equipment of	304
steam cylinder sizes of reciprocating	298
type of drive of vacuum heating	295
types of	287, 289, 294, 303
typical connections for vacuum heating	299, 300, 301
volumetric displacement rate of vacuum heating	295
water capacity of vacuum heating	296
water cylinder sizes of	297, 298

R

Radiant heat	449
Radiation	
amount of, in gas heating	242
calculation of amount of	74, 75
heat, and convection	10, 11
hot water in greenhouses	216, 217
in greenhouse heating systems	215, 216
proportionate for various room temperatures	74
Radiators	
automatic control for direct-indirect	263
application of automatic control to hot water	264
calculation of heat emission of indirect	71, 72
cast iron gravity indirect	71
concealed	66
condensation rate in	75, 76
design of	66
determination of size of	114, 115
direct	66
direct-indirect	66
effect of enclosures with cast iron, on heat emission	77, 78
effect of painting cast iron	76
heat emission of cast iron	65, 67, 68, 69
kind of heat emitting units	65, 66
location and selection of cast iron	72, 73
rating of	66
recessed	66
semi-indirect	66
specifications for cast iron	78
temperature drop	118
useful heat output of	67
Rating	
coal fired boiler	136
for fan furnace heating	193
for gas heating appliances	238, 239
gas fired boiler	137
of air cleaners	440
of boilers for oil fuel	137
of industrial unit heaters	198
Receivers	
volumetric capacity of	389
Recirculation	
of air in ventilation	361
Refrigerating units	
application of automatic control	270
Refrigeration	
cost of	270
Registers	
free area in warm air	174
Relative humidity	
affect on human comfort	377
in ventilation	359
warm air furnace research	179
Risers	
branch	80
effect of reaming	95
water	337
Roof ventilators	
capacities of unit type	478
continuous type of	480
unit type	474
Room temperatures	
in ventilation	362
thermostat	223
Rotary ventilators	476

S

Saturated air	454
Schools	
air for ventilation of	358
unit systems for school work	390
Selecting exhaust fan	
sensible heat	373
Smoke bomb	366
Smokes	
definition of	433
Special problems on drying	456
Spray dryers	450
Stack	
draft from	162
function under natural draft operation	162
ratio of stack area to leader area	172, 173
size of wall	171
Standard method for measuring air velocity	432
Standard of the A. S. H. & V. E.	483
Stationary ventilators	476
Steam	
amount used in federal buildings	354
atomizing in industrial oil burning	228
control of supply in central heating systems	203
distribution	87
flow of, in pipes	86
maximum demand in federal buildings	355
monthly consumption of, in federal buildings	355
supply connections in kitchens	326
Steam requirements	
for heating and humidifying air	435
from outside mains	207, 211
kitchen	324

	Page
Stokers	
self feeding devices	161
types of mechanical	161
Strainers	
oil	231
Styles of roof ventilators	477
Supply	
control of steam	203
Surface	
determination of net outside wall	46
heat insulation for pipes and	247
switch	204
Synthetic air chart	485
data sheet for	487
description of	484
making the test	485
plotting the test data for	488
recommended percentages based on	388
stations for making test	486
Systems	
air sealed or closed hot water	129
air valves for one-pipe gravity steam	81
application of fan furnace, to standard duct systems	190
application of warm air heating	167
boiler protection in vapor	85
capacities of risers for one-pipe low pressure steam	94
capacities of risers for two-pipe low pressure steam	94
central heating	203
connections for one-pipe gravity steam	81
description of piping for steam heating	80
design of gravity circulating warm-air heating systems	167
design problems of steam heating	79, 97
designing a furnace heating	169
determining size of pipe in vacuum pump	106
down-feed of piping	80
downward, of ventilation	361
exhaust	431
gravity for hot water supply	342
gravity, of piping	80
one-pipe gravity steam	80, 81
pipe sizes for hot water	341
piping and connections for two-pipe gravity	82
pressure drop in water	336
return systems for two-pipe gravity	83
rule for design of pipe	116
specifications for heating	7
two-pipe gravity	82
up-feed of piping	80
upward, of ventilation	361
vacuum, of piping	80
vacuum pump	85
vapor	83, 84
vapor, of piping	80
vapor vacuum type	81
ventilation	379
venting valves, vapor	85
warm air heating	167

T

	Page
Tables	
description of pipe size	89, 93, 95, 97
general data on pipe size	88, 89
Tank	
elevation of	339
for industrial oil burning	231
installations in oil burning	226
sizes of	301
storage in federal buildings	350
Temperature	
air, at registers	169
air in ventilation	359
breathing line	4, 5, 6
control of room	262
difference	360, 473
drop in leaders	170, 171
dry bulb	370, 371
effective	357, 359, 371
greenhouse heating	215, 216
humidity and air motion	367
incoming air in ventilation	360
inside air	4, 5
inside for summer	6
inside for winter	4, 5, 6
measuring of duct	362
measuring of room	362
outside air	6, 7, 8, 9
outside in summer	7
outside in winter	6
performance data of regulators	275, 276
wet bulb	370, 371
Temperature and humidity control	434
Theatres	
quantities of air for ventilation	358
Thermometers	
recording	362
Thermostats	
classes of	260
electric	272
pilot type	261
unit type	270
Transmission	
effect of humidity on heat	75
heat coefficients	9, 10, 13, 21, 47
heat, data	13
Traps	
air	309
alternating receiver type	309
arrangement of alternating receiver	309, 310
arrangement of lifting trap	302, 308
arrangement of return trap and receiver	307, 309
by-passes	306
capacity of	306
design of tilting	308
high-pressure	306, 307
lifting	308
low-pressure	308
oil	309
principle of operation	306
types of	306
uses of	306
Tumbler dryers	451
Typical installations of fan system	380

U

	Page
Unit control	
industrial applications of	273
Unit heaters	
air vent in industrial	200
B.t.u. capacity of industrial	198
control of room temperatures in industrial	200
discharge outlets	199
double automatic temperature control	272
for industrial service	391
industrial	197
of industrial	198
pneumatic control of	272
present day tendency of industrial	199
propeller fan type heaters	199
recirculating industrial heaters	198, 199
suspended industrial heaters	199
types of industrial	197, 199
use of industrial	197
Unit systems	389
application of automatic control	263
fan radiator units	263
for public buildings	389
for school work	390
fresh air intakes	263
Unit type	
roof ventilators	474
Units	
air conditioning	200
dehumidifying work in air conditioning	201
design of air conditioning	201
direct fired	200
flow of air in air conditioning	201
kinds of heat emitting	65, 66
spray water in air conditioning	201

V

	Page
Vacuum dryers	450
Vacuum heating pumps	
air capacities of	295
air capacity measurements of	296
air test	296

	Page
arrangement for	298, 299
capacity of receiving tanks	295, 296
discharge from reciprocating vacuum heating pumps	298
location of receiving tank	295
piston speed	295
steam cylinder sizes of reciprocating vacuum pumps	298
steam driven vacuum pump size determination	297
type of drive	295
types of	294
typical connections	299, 300, 301
volumetric displacement rate	295
water capacity of	296
water cylinder sizes of steam driven	297, 298
Valves	98
pressure reducing in central heating systems	204
vaporizing oil burner	222
Velocity	
air duct, for forced draft	163, 164
air in public buildings	423
effect of air, on surface losses	254, 257
general statement on temperature and wind	7
maximum	88
pressure readings	365
wind	20, 47, 48
Ventilating systems	
classification of	379
design of mechanical	359
Ventilation	
air changes	358
air cooling	360
air motion	359
air movement	366
air purity	359
air supply for	358
air temperature	359
anemometers	364
atmospheric dust	363
bacteria	363
CO_2 determinations	363
control of	481
dairy stable	480
downward system of	361
dry bulb temperature	370, 371
effect of air motion on comfort	369
effective temperature	357, 359, 371
elimination of noise	361
equal comfort lines	368
factors affecting health and comfort	367
factors affecting loss of body heat	367
for personal comfort and health	362
freedom from gases	359
freedom from odors	359
functions of air	359
gages or manometers	365
general requirements of	357
heat from occupants, lights, etc.	360
human comfort	367
humidity	362
humidity readings	363
kata-thermometer	366
measuring duct temperatures	362
measuring of room temperatures	362
Ventilation	
mechanical exhaust	359
mechanical in federal buildings	351
natural	471
natural forces in	471
ozone in	441
physiological effects of	366
pitot tubes	364
problem of	360
problem of cooling	360
psychological factor in	361
psychrometer	362
psychrometric chart with effective temperature lines for	368, 378
psychrometric chart with effective temperature lines for 100 ft. air velocity	369
psychrometric chart with effective temperature lines for 300 ft. air velocity	370
quantities of air required for	358
recirculation of air	361
recording thermometers	362
relative humidity	359
science of	357
smoke bomb	366
suggestions in planning	473
synthetic air chart	366
systems of	379
temperature difference	360
temperature, humidity and air motion	367
temperature of incoming air	360
testing air flow	364
to obtain effective	479
total body heat loss	367, 368
upward system of	361
use of comfort charts	370, 371
velocity pressure readings	365
volumetric air measurements	364
wet bulb temperatures	370, 371
Ventilator	
air-turbine	478
rotary	476
stationary	476
styles of rotary	478
various styles of	477
Viscous filters	
automatic	439
operating principle of	436
Volumetric air measurements	364

W

	Page
Warm air furnaces	
application of code to gas burning	236
area of flue lining	158
construction of gas burning	235
Warm air registers	174
Water	
amount through pipes	336, 338
kitchen connections	326
pressure drop in systems	336
purification by ozone	448
requirements for kitchens	324
risers	337
viscosity of	282, 283
amount of water passed through pipes	336, 338
Water supply	
apartment buildings, hot water requirements	341
apartment houses, sizes of mains and meters	338
branch sizes for fixtures and maximum flow	335, 336
estimating pipe size for any part of riser	335, 336
example of sizing of main	336
formulae	340
gravity systems	342
hospitals, water requirements for	342
hospitals, hot water requirements for	342
hotels, hot water requirements for	341
mains, sizes of hot water	342
office buildings, hot water requirements for	341
pipe sizes, for hot, systems	341
pipes, size of for any pressure drop	338
principle in determining pipe sizes	335
risers for manufacturing buildings, hotels, etc.	337
risers for apartment houses	337
total pressure	335
water pressure	339
Wind	
action in ventilation	471
effect of	47
movement	47
velocity	20, 47, 48

CODE *of* ETHICS *for* ENGINEERS

ENGINEERING work has become an increasingly important factor in the progress of civilization and in the welfare of the community. The engineering profession is held responsible for the planning, construction and operation of such work and is entitled to the position and authority which will enable it to discharge this responsibility and to render effective service to humanity.

That the dignity of their chosen profession may be maintained, it is the duty of all engineers to conduct themselves according to the principles of the following Code of Ethics:

1—The engineer will carry on his professional work in a spirit of fairness to employees and contractors, fidelity to clients and employers, loyalty to his country and devotion to high ideals of courtesy and personal honor.

2—He will refrain from associating himself with or allowing the use of his name by an enterprise of questionable character.

3—He will advertise only in a dignified manner, being careful to avoid misleading statements.

4—He will regard as confidential any information obtained by him as to the business affairs and technical methods or processes of a client or employer.

5—He will inform a client or employer of any business connections, interests or affiliations which might influence his judgment or impair the disinterested quality of his services.

6—He will refrain from using any improper or questionable methods of soliciting professional work and will decline to pay or to accept commissions for securing such work.

7—He will accept compensation, financial or otherwise, for a particular service, from one source only, except with the full knowledge and consent of all interested parties.

8—He will not use unfair means to win professional advancement or to injure the chances of another engineer to secure and hold employment.

9—He will cooperate in upbuilding the engineering profession by exchanging general information and experience with his fellow engineers and students of engineering and also by contributing to work of engineering societies, schools of applied science and the technical press.

10—He will interest himself in the public welfare in behalf of which he will be ready to apply his special knowledge, skill and training for the use and benefit of mankind.

ST. LOUIS PUBLIC LIBRARY APR 9 1930

AMERICAN SOCIETY OF HEATING *and* VENTILATING ENGINEERS GUIDE 1929

INTRODUCTION *to* AND SUGGESTIONS *for* THE EFFECTIVE USE OF THE GUIDE, 1929

THIS is the seventh consecutive Annual Edition of THE GUIDE. It is presented to the Profession and its allied Industries with the hope that it will perform a real and important service to their advancement.

THE GUIDE was founded in 1922 and from the very beginning was dedicated to service, rather than commercialism. Its principles, then and now, are definite and have been followed without deviation, despite the many inhibitions of tradition and commercialism. These principles, though plural in expression, are singular in effect;—that everything must be subordinated to facts and service, rather than to commercialism. These principles are based on the conviction that *service* with *facts* is the life-blood of *both* the Profession and its allied Industries.

The users of THE GUIDE will find therefore, that the *Text Section* contains substantially all of the very latest and most reliable data on *Heating and Ventilating;* compiled from the findings of the Society's Research Laboratory and of other independent Laboratories, from the experience of the foremost Engineers and from similar sources of reliable information; all put into most available and readily usable form for the convenience of the busy Architect, Engineer, Manufacturer, Contractor or Builder.

The data presented in the Text Pages in each issue of THE GUIDE thus represents the best available information, having its source in individual engineering experience, in that collective experience garnered by Manufacturers, and in the devoted labors of the Society's own Research Laboratory at Pittsburgh, in collaboration with the United States Bureau of Mines,—data prepared and contributed freely by the foremost engineers of the United States,—perhaps it would not be exaggerative to say, of the world. In no other way, save through the medium of this Society,—unfettered by commercialism or self-interest,—could the liberal cooperation of these men have been elicited.

We are proud that THE GUIDE has won the loyalty and cooperation of the many who have labored so generously and unselfishly that its Text Pages may serve usefully and effectively to advance the interests of the Profession, its allied Industries and that vast Public which we are privileged to serve.

In the Catalog Data Section, we have insisted again that the Manufacturer's data presented must be useful, *serviceable*,—not a mere collection of claims, high-sounding catch phrases or superlatives, but an informative presentation of helpful *data*. At first, when the Manufacturer felt that he might use his paid-for space as he pleased, this

was a difficult problem. We are extremely gratified that, before our persistence and enthusiasm, the difficulties have been transformed into inspiring cooperation. We are proud that in the Catalog Data Pages of THE GUIDE, the Engineer, Architect, Contractor or Builder can find authoritative, *serviceable* data which he can use effectively in the selection of material or equipment, and in the general design of installations. We feel that this pride is justified because it has been *earned*,—through devotion to principles and unremitting efforts to prove them. We are, too, very grateful to those far-seeing, broadminded manufacturers who have joined with us in this enterprise, the sole object of which is service to and advancement of the Art of Heating, Ventilating and Air Conditioning,—an Art now immutably associated with the comfort, health and happiness of practically every man, woman and child in the civilized world.

These manufacturers, whose Catalog Data appear in THE GUIDE, pay for the service rendered to them as effective advertising, and the support and cooperation of these prescient manufacturers constitute an important part of the means whereby the American Society of Heating and Ventilating Engineers is enabled to achieve the publication and wide distribution of THE GUIDE,—whereby the Society has been enabled to extend its wholly philanthropic services to the general advancement of the Profession and its allied Industries, the one entirely dependent upon the other and both, jointly, essential to the general interests of the public. To them, our whole-hearted acknowledgements.

Thus, through the splendid cooperation of its Members, backed by that of allied Manufacturers, The Society is enabled to extend its service and influence in a manner otherwise impossible,—to contribute signally to the advancement of those ideals which inspired its founders and have been perpetuated in its membership.

In this edition every Text Chapter has been carefully revised in accordance with current knowledge and all useful data which have become available since the last edition have been added. Arrangement and indexing have had intensive study and "The Index of the Technical Data Sections" (pp. iv to xiii), has been made as comprehensive as possible. Likewise the Index to the *Catalog Data Section* (pp. 495 to 818) and the Index to *Modern Heating and Ventilating Equipment* (pp. 819 to 840) have been revised and amplified. The use of these Indices will greatly augment the utility of the work, with regard to any particular purpose. While we feel a perusal of all the Text and Catalog Data Pages will amply reward the time so employed, we suggest that the Indexes provide a quick and convenient means of access to reliable information upon such specific subjects as may be of immediate importance to the user.

It is recommended that use be made of the *Catalog Data* to supplement the *Text Data* on any subject, as it will be found to contain much of the engineering data on sizes, shapes, capacities, dimensions, space requirements, applications and installations, so useful in the planning, specifying and installation of mechanical equipment.

It is also suggested that the cross references in the Text always be used, as they have been very carefully planned to give ready access to the data contained in other Chapters which may be useful in connection with the particular Chapter in question.

Also that the notes and explanations (especially those applicable to Tables) be studied, as in the interest of brevity and simplicity certain data have been made to serve many purposes by the use of these notes, but at the same time may be susceptible to improper use if not fully understood.

We are more than gratified that THE GUIDE has been adopted in many Schools, Colleges and Universities, as a standard Text Book, more than four hundred copies of the last Edition being so employed. In appreciation, we pledge ourselves to unflagging efforts that we may continue to merit this unusual recognition.

We invite and will welcome constructive criticism from every source.

More than nine thousand (9000) copies of this Issue will be published and distributed with the sincere hope that the generous efforts of the Contributors and the ready cooperation of the represented Manufacturers will be more than requited in services rendered to the general advantage of the Profession, the Associated Industries and the Public-at-large.

GUIDE PUBLICATION COMMITTEE

PERRY WEST, *General Chairman and Editor-in-Chief*

C. V. HAYNES W. H. CARRIER
Vice-Chairmen

CHAPTER I

HEAT LOSSES FROM BUILDINGS

Data on Inside and Outside Temperatures, Heat Transmission Coefficients, Theory of Heat Transfer, Infiltration and Wind Effects, Heat Conductivity Tables for Various Building Construction.

INTRODUCTION

THE latest authoritative data on conductivities of building and insulating materials, have been used in the revision and enlargement of this chapter of THE GUIDE 1929. To the standard tables of heat transmission coefficients computed last year data for several new types of constructions have been added so that the figures for modern walls, roofs, ceilings, floors and partitions, both insulated and uninsulated are the most complete extant.

Much fundamental research work is now under way, especially on surface factors and data from these investigations should prove useful in future editions, but are not as yet complete or definite enough for use in THE GUIDE.

CALCULATING HEAT LOSSES

The procedure to be followed in determining the heat loss from any building can be divided into seven consecutive steps, as follows:

1. Determine on the inside air temperature, at the breathing line, which is to be maintained in the building during the coldest weather. See Table 1, p. 4.

2. Determine on an outside air temperature for design purposes, based on the minimum temperatures recorded in the locality in question, which will provide for all but the most severe conditions. Such conditions as may exist for only a few consecutive hours are readily taken care of by the heat capacity of the building itself. See Table 3, p. 8.

3. Select or compute the heat transmission coefficients for outside walls and glass, also for inside walls, floors, or top-floor ceilings, if these are next to unheated space. Include roof if next to heated space. See pages 22 to 45 and Tables 7 to 12.

4. Measure up net outside wall, glass and roof next to heated spaces, as well as any cold walls, floors or ceilings next to unheated space. Such measurements are made from building plans, or from the actual building.

5. Compute the heat transmission losses for each kind of wall, glass, floor, ceiling and roof in the building by multiplying the heat transmission coefficient in each case

---

Data for this Chapter of THE GUIDE originally prepared by Arthur C. Willard, Professor of Heating and Ventilation and Head of Department of Mechanical Engineering, University of Illinois.

The work of compiling and computing Tables 7–12, in accordance with the methods set forth in the text was done by P. D. Close.

The material for this edition has been revised by the following committee: Prof. F. B. Rowley, *chairman;* H. S. Ashenhurst, P. D. Close, Prof. A. P. Kratz, Prof. G. L. Larson, L. B. Lent, E. C. Lloyd, H. P. Reid, E. N. Sanbern, C. G. Segeler and M. S. Wunderlich.

by the area of the surface in square feet and the temperature difference between the inside and outside air. (See paragraphs 1 and 2.)

6. Select unit values and compute the heat equivalent of the infiltration of cold air taking place around outside doors and windows. These unit values depend on kind or width of crack and wind velocity, and when multiplied by the length of crack and the temperature difference between the inside and outside air, the result expresses the heat required to warm up the cold air leaking into the building per hour. See pages 47 to 60 and Tables 14 to 19.

7. The sum of the heat losses by transmission (paragraph 5) through the outside wall and glass, as well as through any cold floors, ceilings or roof, and the heat equivalent (paragraph 6) of the cold air entering by infiltration represents the total heat loss equivalent for any building.

The above are the heat losses after the building is heated and under stable operating conditions, in coldest weather. Additional heat is required for raising the temperature of the air, the building materials and the material contents of the building to standard inside temperature.

The rate at which this additional heat is required depends upon the heat capacity of the structure and its material contents and upon the time in which these are to be heated.

This additional heat may be figured and allowed for as conditions require, but inasmuch as the heating system proportioned for taking care of the above heat losses will usually have a capacity about 100 per cent greater than that required for average winter weather, and inasmuch as most buildings may either be continuously heated or more time be allowed for heating up, during the few minimum temperature days, no allowance is made except in the size of boilers or furnaces.

INSIDE TEMPERATURES FOR WINTER[1]

The inside air temperature which must be maintained within a building and which should always be stated in the heating specifications, is understood to be the temperature at the breathing line 5 ft. above the floor and not less than 3 ft. from the outside walls. Inside air temperatures usually specified vary in accordance with the use to which the building is to be put, and Table 1 presents values which are in conformity with good practice.

In connection with inside temperatures for winter where humidifying means are provided, approximately 1 deg. variation for each 10 per cent variation in relative humidity should be provided. For example, if the relative humidity is raised from a condition of 15 per cent to one of 45 per cent by artificial humidification it is desirable to lower the indoor temperature about 3 deg. as indicated by the Effective Temperature Line on the Comfort Chart. (See Chapter XXIII, p. 357.) The temperatures given in the table are for normal dry air with dew-points approximately equivalent to outdoor air. A reduction in the temperatures will be required corresponding to the raise of the moisture content by artificial humidification.

In making the actual heat loss computations, however, for the various rooms in a building it is often necessary to modify the temperatures given in Table 1 so that the air temperature at the proper level will be

[1]Material for inside and outside temperatures prepared especially for THE GUIDE by the following committee: W. H. Carrier, *chairman*; Prof. A. R. Acheson, R. S. Franklin, Dr. E. V. Hill and S. R. Lewis.

TABLE 1. INSIDE TEMPERATURES USUALLY SPECIFIED

TYPE OF BUILDING	DEG. FAHR.
SCHOOLS—	
Class Rooms	68
Assembly Rooms	66 – 68
Gymnasiums	55 – 65
Toilets and Baths	70
Wardrobe and Locker Rooms	65 – 68
Kitchens	66
Dining and Lunch Rooms	65 – 68
Playrooms	60 – 65
Natatoriums	75
THEATRES—	
Seating Space	68 – 72
Lounge Rooms	68
Toilets	68
HOSPITALS—	
Private Rooms	70
Private Rooms (surgical)	70 – 80
Operating Rooms	70 – 95
Wards	68
Kitchens and Laundries	66
Toilets	68
Bathrooms	70 – 80
HOTELS—	
Bedrooms and Baths	70
Dining Rooms	70
Kitchens and Laundries	66
Ball Rooms	65 – 68
Toilets and Service Rooms	68
HOMES—	
Where 68 deg. is generally the desirable standard of temperature a guarantee of 70 deg. is customarily exacted.	
STORES	65 – 68
PUBLIC BUILDINGS	68 – 70
WARM AIR BATHS	120
STEAM BATHS	110
FACTORIES AND MACHINE SHOPS	60 – 65
FOUNDRIES AND BOILER SHOPS	50 – 60
PAINT SHOPS	80

used. By "air temperature at the proper level" is meant, in the case of walls, the air temperature at the mean height between floor and ceiling; in the case of glass, the air temperature at the mean height of the glass; in the case of roof or ceiling, the air temperature at the mean height of the roof or ceiling above the floor of the heated room, and in the case of floors, the air temperature at the floor level. In the case of heated spaces adjacent to unheated (no heat of any kind) spaces, it will usually be sufficient to assume the temperature in such spaces as the mean between the temperature of the inside heated spaces and the outside air temperature.

The air temperature at the mean height between floor and ceiling is the "breathing-line" temperature, Table 1, for rooms not over 10 ft. in

Table 2. Desirable Indoor Temperatures in Summer Corresponding to Outdoor Temperatures

Degrees Outside	Degrees Inside		
Dry Bulb	Dry Bulb	Wet Bulb	Effective Temperature
95	80.0	65.2	73.4
90	78.0	64.5	72.2
85	76.5	64.0	71.1
80	75.0	63.5	70.2
75	73.5	63.0	69.3
70	72.0	62.5	68.2

height. For rooms above this height, add 2 per cent per foot of height to the breathing-line temperature for each foot or fraction of a foot difference between the mean height of the vertical wall, glass, roof or ceiling surface, and the height of the breathing line.

In determining mean air temperatures just above floors which are next to ground or unheated spaces, a temperature 5 deg. lower than breathing-line temperature may be used, provided breathing-line temperature is not less than 55 deg. fahr.

INSIDE TEMPERATURES FOR SUMMFR

Where buildings are being artificially cooled for human comfort during the summer a different scale of inside temperatures is required and this inside temperature must depend to a large extent upon the variation in outside temperatures. It is manifestly undesirable and impracticable to maintain a temperature of 70 deg. inside when it is 95 deg. outside, nor can it be said that the inside temperature should be maintained 15 deg. below the outside temperature. At 95 deg. outside and dry air, a temperature somewhat lower than 80 deg. might be desirable. On the other hand with 85 deg. outside a 70 deg. temperature inside would be entirely too cold. In other words, the spread between the inside and outside temperature must be varied as the outside temperature varies.

Table 2 is based on average moisture conditions outside and upon the assumption of relative humidities inside, between 50 and 60 per cent, which is usual in such installations.

OUTSIDE TEMPERATURES IN WINTER

The outside air temperature used in computing the heat loss from a building is seldom taken as the lowest temperature ever recorded in a given locality. Such temperatures are usually of short duration and are rarely repeated in successive years. It is therefore evident that a temperature somewhat higher than the lowest on record may be properly assumed in making the heat loss computations.

The outside temperature to be assumed in the design of any heating system must not be more than 15 deg. fahr. above the lowest recorded temperature as reported by the U. S. Weather Bureau (Table 3) during the preceding 10 years for the locality in which the heating system is to be installed. The outside temperature assumed and used in the design should always be stated in the heating specifications.

If U. S. Weather Bureau reports are not available for the locality in question, then the U. S. Weather Bureau reports for the station nearest to this locality are to be used, unless some other temperature is specifically stated in the specifications.

In computing the *average* heat transmission losses for the heating season the average outside temperature from October 1 to May 1, shall be used. This is to be that reported by the U. S. Weather Bureau during the preceding 10 years, for the locality in question.

GENERAL STATEMENT ON TEMPERATURES AND WIND VELOCITY

In order that no misunderstanding may occur, the specifications for all heating systems or plants shall include a clause covering the following points:

1. The lowest recorded outside temperature in the locality, as reported by the U. S. Weather Bureau for the preceding 10 years;

2. The outside air and inside breathing-line temperatures which were assumed and actually used in making the heat loss computations;

3. The heating load should be calculated on a temperature not more than 15 deg. above the minimum outside temperature recorded for the locality for the preceding 10 years and at a wind velocity which is the highest recorded in the locality for such temperature (i.e., for a temperature 15 deg. above the minimum) for the locality in which the heating plant is located. Both wind velocity and direction are to be taken from the U. S. Weather Bureau records of 10 years.

OUTSIDE TEMPERATURES IN SUMMER

The maximum cooling load in summer may be calculated for an outside dry bulb temperature not to exceed 95 deg. and a wet bulb temperature not to exceed 77 deg. While higher outside dry bulb temperatures are frequently observed they are either of short duration or accompanied by low relative humidities. Weather Bureau reports are frequently misleading in this respect as they report the maximum temperature for the day with the relative humidity which occurs during a different period and which usually is much higher than the relative humidity occurring at the maximum temperature. Any statement of weather conditions which gives a wet bulb temperature higher than 80 deg. in the United States is questionable.

HEAT TRANSMISSION COEFFICIENTS

Definition

The amount of heat expressed in B.t.u. which is transmitted in 1 hour per square foot of the material as used in the building, for a difference in temperature of 1 deg. fahr. between the air on the inside and outside of the building, is called the coefficient of heat transmission for the material. The heat transmission coefficient for any given building material depends upon the structure of the material and its density. Heavy or dense materials, the weight of which per cubic foot is high, usually transmit more heat than light or less dense materials, the weight of which per cubic foot is low.

Table 3. Climatic Conditions Compiled from U. S. Weather Bureau Records

Col. A	Col. B	Col. C	Col. D	Col. E	Col. F
State	City	Average Temp., Oct. 1st–May 1st	Lowest Temperature	Average Wind Velocity Dec., Jan., Feb., Miles per Hr.	Direction of Prevailing Wind, Dec., Jan., Feb.
Ala.	Mobile	57.7	−1	8.3	N
	Birmingham	53.9	−10	8.6	N
Ariz.	Phoenix	59.5	16	3.9	E
	Flagstaff	34.9	−25	6.7	SW
Ark.	Fort Smith	49.5	−15	8.0	E
	Little Rock	51.6	−12	9.9	NW
Cal.	San Francisco	54.3	29	.....	N
	Los Angeles	58.6	28	.....	NE
Colo.	Denver	39.3	−29	7.4	S
	Grand Junction	39.2	−16	5.6	SE
Conn.	New Haven	38.0	−14	9.3	N
D. C.	Washington	43.2	−15	7.3	NW
Fla.	Jacksonville	61.9	10	8.2	NE
Ga.	Atlanta	51.4	−8	11.8	NW
	Savannah	58.4	8	8.3	NW
Idaho	Lewiston	42.5	−13	4.7	E
	Pocatello	36.4	−20	9.3	SE
Ill.	Chicago	36.4	−23	17.0	SW
	Springfield	39.9	−24	10.2	NW
Ind.	Indianapolis	40.2	−25	11.8	S
	Evansville	44.1	−15	8.4	S
Iowa	Dubuque	33.9	−32	6.1	NW
	Sioux City	32.1	−35	12.2	NW
Kans.	Concordia	38.9	−25	7.3	N
	Dodge City	40.2	−26	10.4	NW
Ky.	Louisville	45.2	−20	9.3	SW
La.	New Orleans	61.5	7	9.6	N
	Shreveport	56.2	−5	7.7	SE
Me.	Eastport	31.1	−23	13.8	W
	Portland	33.6	−17	10.1	NW
Md.	Baltimore	43.6	−7	7.2	NW
Mass.	Boston	37.6	−13	11.7	W
Mich.	Alpena	29.1	−27	11.3	W
	Detroit	35.4	−24	13.1	SW
	Marquette	27.6	−27	11.4	NW
Minn.	Duluth	25.1	−41	11.1	SW
	Minneapolis	29.6	−33	11.5	NW
Miss.	Vicksburg	56.0	−1	7.6	SE
Mo.	St. Joseph	40.3	−24	9.1	NW
	St. Louis	43.3	−22	11.8	NW
	Springfield	43.0	−29	11.3	SE
Mont.	Billings	34.7	−49	.....	W
	Havre	27.7	−57	8.7	SW
Nebr.	Lincoln	37.0	−29	10.9	N
	North Platte	34.6	−35	9.0	W
Nev.	Tonopah	39.6	−7	9.9	SE
	Winnemucca	37.9	−28	9.5	NE
N. H.	Concord	33.4	−35	6.0	NW
N. J.	Atlantic City	41.6	−7	10.6	NW
N. Y.	Albany	35.1	−24	7.9	S
	Buffalo	34.7	−14	17.7	W
	New York	40.3	−6	13.3	NW
N. M.	Santa Fe	38.0	−13	7.3	NE

Table 3. Climatic Conditions Compiled from U. S. Weather Bureau Records—(Continued)

Col. A	Col. B	Col. C	Col. D	Col. E	Col. F
State	City	Average Temp., Oct. 1st–May 1st	Lowest Temperature	Average Wind Velocity Dec., Jan., Feb., Miles per Hr.	Direction of Prevailing Wind, Dec., Jan., Feb.
N. C.	Raleigh	49.7	−2	7.3	SW
	Wilmington	53.1	5	8.9	SW
N. D.	Bismark	24.5	−45	.....	NW
	Devil's Lake	18.9	−44	11.4	W
Ohio	Cleveland	36.9	−17	14.5	SW
	Columbus	39.9	−20	9.3	SW
Okla.	Oklahoma City	48.0	−17	12.0	N
Ore.	Baker	34.1	−20	6.0	SE
	Portland	45.9	−2	6.5	S
Pa.	Philadelphia	41.9	−6	11.0	NW
	Pittsburgh	40.8	−20	13.7	NW
R. I.	Providence	37.6	−9	14.6	NW
S. C.	Charleston	56.9	7	11.0	N
	Columbia	53.7	−2	8.0	NE
S. D.	Huron	28.1	−43	11.5	NW
	Rapid City	32.3	−34	7.5	W
Tenn.	Knoxville	47.0	−16	6.5	SW
	Memphis	50.9	−9	9.6	NW
Texas	El Paso	53.0	−2	10.5	NW
	Fort Worth	54.7	−8	11.0	NW
	San Antonio	60.7	4	8.2	N
Utah	Modena	38.1	−24	8.9	W
	Salt Lake City	40.0	−20	4.9	SE
Vt.	Burlington	29.3	−27	12.9	S
Va.	Norfolk	49.1	2	9.0	N
	Lynchburg	45.2	−7	5.2	NW
	Richmond	47.4	−3	7.4	S
Wash.	Seattle	45.3	3	9.1	SE
	Spokane	37.5	−30	.....	SW
W. Va.	Elkins	38.8	−21	4.8	W
	Parkersburg	41.9	−27	6.6	S
Wis.	Green Bay	28.6	−36	12.8	SW
	La Crosse	31.2	−43	5.6	NW
	Milwaukee	33.0	−25	11.7	W
Wyo.	Sheridan	31.0	−45	5.3	NW
	Lander	28.9	−36	3.0	NE

Transmission Coefficients

By means of suitable tests on actual wall, roof, floor and ceiling constructions, heat transmission coefficients may be determined directly, or they may be computed if certain physical constants are known. If tests are made to determine heat transmission coefficients, the inside and outside air temperatures should correspond with those actually existing in heating practice, and the amount of air movement, both on the inside and outside of the test wall, should be definitely stated in reporting the coefficients. Since actual temperature differences vary widely in different parts of the country, it is desirable to adopt some standard basis for testing, such as 80 deg. inside and 0 deg. outside, and in very precise work

make a correction for other temperatures. It has been found that the absolute mean temperature of the wall affects the coefficient materially. The coefficient increases with the absolute mean temperature.

Tests are usually run under still air conditions, which means there was no wind movement, during the test, over the surfaces of the wall. In practice, some wind movement over the exterior surface of the wall should always be allowed for; hence *still air* coefficients cannot be used in actual work as they do not provide for the normal wind movement over the outside of the building in the locality in question during the heating season. Moreover, *still air* transmission coefficients cannot be corrected to provide for moving air conditions by multiplying by a single constant factor.[2]

The coefficients of heat transmission of various types of construction as given in Tables 7 to 13, are for still air for inside walls, floors and ceilings and for a wind movement of 15 miles per hour for exterior walls and roofs and are generally applicable to heat transmission computations using equation (9). Such heat transmission coefficients are always based on the difference between the air temperatures on the inside and the outside of the wall.

Transmission Coefficients by Computation

If heat transmission coefficients are to be computed, and in many, if not most cases, they should be computed, the following analysis of the transmission of heat through a simple, solid wall is used as the basis for such computations.

The diagram in Fig. 1 exhibits four important temperatures: *First* the air temperature t inside of the building; *second*, the temperature t_1 of the inside surface of the wall; *third*, the temperature t_2 of the outside surface of the wall, and *fourth*, the air temperature t_0 outside of the building. Heat reaches or enters the inside surface of the wall by radiation and convection, since the air and objects A within the building are *always* warmer than the inside surface of the wall, when the inside air temperature t is greater than the outside air temperature t_0. This heat must then pass through the material of the wall from inside to outside surface by conduction, and is finally given off from the outside surface by radiation and convection, provided, of course, that equilibrium has been established and all four temperatures are constant.

The amount of heat reaching or entering the wall per hour depends on t and t_1 and a coefficient K_1 varying with the character of the wall material. K_1 may be defined as the B.t.u. per hour entering each square foot of wall surface per degree difference between the inside air temperature t and the inside surface temperature t_1. Hence the heat received by inner surface of the wall per hour by both radiation and convection is

$$H_1 = K_1 (t - t_1) S \qquad (1)$$

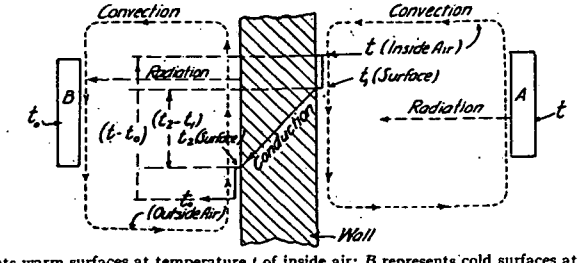
where S is the inner wall surface area in square feet and the other terms are as heretofore indicated.

[2] "Effect of Wind on Heat Transmission Coefficients" in Appendix to Section III, Code of Minimum Requirements of the AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS.

Whatever amount of heat H_1 enters the inner wall surface must be given off from the outer wall surface, so that if H_2 represents heat emitted from outer surface

$$H_1 = H_2 = K_2 (t_2 - t_0) S. \qquad (2)$$

Now K_2 may not equal K_1, in which case $(t_2 - t_0)$ will not equal $(t - t_1)$. Usually, in an actual wall exposed to wind on the outside, K_2 (Table 6) is greater than K_1 and $(t_2 - t_0)$ must be less than $(t - t_1)$. Moreover, the heat H_c passing through the wall by conduction is equal to H_1 and H_2, and if C is the coefficient of conduction = B.t.u. transmitted per hour



A represents warm surfaces at temperature t of inside air; *B* represents cold surfaces at temperature t_0 of outside air. For an actual temperature gradient curve see Fig. 2.

FIG. 1. TEMPERATURE CURVE OR GRADIENT FROM AIR INSIDE TO AND THROUGH WALL TO AIR OUTSIDE, WALL MATERIAL ASSUMED AIR-TIGHT

per square foot of material per 1 in. thickness per degree difference between the surface temperatures, then

$$H_1 = H_2 = H_c = \frac{C}{x} (t_1 - t_2) S \qquad (3)$$

where x = wall thickness in inches.

These equations (1), (2) and (3) are fundamental and are used for determining values for K_1, K_2 and C for actual wall materials by test. They cannot be used for computing heat losses in an actual building, since the surface temperatures t_1 and t_2 are seldom known, although these surface temperatures can be determined in a test by means of thermocouples. Hence, for actual conditions where the only temperatures known are the inside and outside air temperatures t and t_0, it is necessary to use a transmission coefficient U = B.t.u. transmitted per hour per square foot of wall surface per degree difference between the inside and outside air temperatures. Values of U for many common types of construction are given in Tables 7 to 13. The heat H transmitted per hour from air inside to air outside is then computed as follows:

$$H = U (t - t_0) S \qquad (4)$$

and since $H = H_1 = H_2 = H_c$, the right hand members of equations (1), (2), (3) and (4) are all equal.

The coefficient U may be determined by test, or it may be computed for any wall provided values for K_1, K_2 and C are known. By proper substitution in the four equations, the unknown temperatures t_1 and t_2

can be eliminated and the value of the transmission coefficient for a simple wall x inches thick is

$$U = \frac{1}{\frac{1}{K_1} + \frac{1}{K_2} + \frac{x}{C}} \tag{5}$$

and for a compound wall of several materials having thickness in inches of x_1, x_2, x_3, etc., the coefficient is

$$U = \frac{1}{\frac{1}{K_1} + \frac{1}{K_2} + \frac{x_1}{C_1} + \frac{x_2}{C_2} + \frac{x_3}{C_3} + \text{etc.}} \tag{6}$$

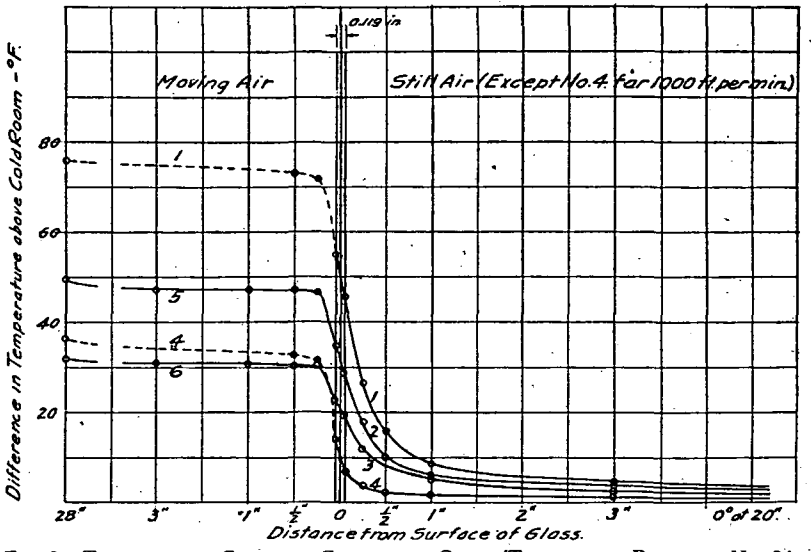


FIG. 2. TEMPERATURE GRADIENT CURVES FOR GLASS (TAKEN FROM BULLETIN NO. 24, ENGRG. EXP. STA., PENNSYLVANIA STATE COLLEGE)

As in the case of the simple wall, K_1 and K_2 are always the inside and outside surface coefficients for the two materials in contact with air. If the air is still (no wind), then for the same material K_1 and K_2 are the same, and $K_1 = K_2$; but if the outside air is in motion then K_2 is always greater than K_1 and will increase as the wind velocity increases. Values for K_1 in still air as determined by various investigators are given in Table 4. Values for C, the conductivity of building materials, are given in Table 5, and are taken from the published values of various investigators. It should be noted that values of C as well as U are dependent on the temperature range, and it is therefore desirable that the investigator determine conductivity values when the wall is subjected to an air temperature of about 70 deg. fahr. on the inside and about zero on the outside.

TABLE 4. SURFACE COEFFICIENTS (K_1) FOR VARIOUS BUILDING MATERIALS UNDER STILL AIR (NO WIND) CONDITIONS

The values in the table are in B.t.u. per square foot of wall surface per hour per 1 deg. fahr. difference between the mean air temperature in the room and the inside surface temperature of the wall.

Building Material	Surface Coefficient K_1 (Still Air) Harding and Willard	Wood
Asbestos (sheet)	1.40	.....
Brickwork (ordinary)	1.40	.....
Cement Plaster (finished)	0.93	.....
Concrete	1.30	.....
Corkboard	1.25	1.20
Glass (window)	1.50	1.90*
Magnesia (blocks)	1.45	.....
Wood (finished surface)	1.40	.....
Building paper	.....	1.40
Average of all values	1.34	.....

*Average of both sides of glass 0.12 in. thick and for 70 deg. fahr. total temperature difference from air to air with moving air on one side. Probable value for still air on both sides 1.60.

In the case of air space construction, two additional surface coefficients for each air space must be inserted in either equation (5) or (6). These surface coefficients may be taken the same as the K_1 (still air) values for the materials forming the sides of the air spaces; thus for a simple wall with one air space,

$$U = \frac{1}{\frac{1}{K_1} + \frac{1}{K_2} + \frac{1}{K_1} + \frac{1}{K_1} + \frac{x}{C}} \tag{7}$$

or

$$= \frac{1}{\frac{3}{K_1} + \frac{1}{K_2} + \frac{x}{C}} \tag{8}$$

With certain very special forms of construction which have irregular air spaces, it is necessary to use the conductivity for the unit construction as actually assembled in the wall. This condition exists when hollow tile is used as furring, in which case $\frac{x_1}{C_1}$ is replaced by $\frac{1}{C_u}$, where C_u is the unit conductivity. (*See footnote 2 of Table 5.*)

Heat Transmission Data

As previously stated heat transmission coefficients of many common types of building construction are given in Tables 7 to 13, inclusive, each construction being identified by a serial number. For example, in Table 7-A, the coefficient of transmission (U) of a 13-in. brick wall, furring strips, and ¾ in. of gypsum plaster on metal lath, is 0.185, and the number assigned to a wall of this construction is 3-b.

The coefficients in these tables were determined by computations similar to those shown in Fig. 3, using the value of C (or C_u) indicated[3]. The authorities for the conductivities used for computing these coefficients

[3] C_u is the conductivity (or conductance) for construction or thickness stated.

are given in Table 5. As in the case of the examples in Fig. 3, the average value of 1.34 given in Table 4 for K_1 was used for all surfaces in still air. The value of K_3 for outside wall and roof surfaces was taken as $3 \times K_1$, or 4.02, corresponding to a wind velocity of approximately 15 miles per hour.

A value of $C = 8.3$ for stone concrete (1- 2- 4 mix) was used for computing the values of U for all constructions involving this material. It is quite probable that the true conductivity of stone concrete approaches the value of 6.3 obtained from tests conducted by Professor Peebles of Armour Institute, when the concrete is thoroughly dry and well cured. If, for a certain concrete construction, it appears that the value of 6.3 is more nearly correct, the engineer may at his discretion compute the value of U on the basis of this figure. This of course is true of other constructions.

The Research Laboratory of the AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS has developed an apparatus known as the Nicholls heat meter for the determination of the heat loss through any type of construction, and by means of which the value of U for any construction may be ascertained by actual test. The Nicholls heat meter consists essentially of a plate of bakelite, 2 ft. square and ⅛ in. thick. This plate is equipped with thermocouples which are so constructed as to operate as differential pyrometers. A difference in temperature between the two surfaces of the plate produces a difference in electrical potential between the thermocouples.

The plate is calibrated so that this difference in potential, when measured, can be converted into terms of heat transmission through the plate. In connection with this plate, it is also necessary to use several other thermocouples to give the temperature of the air within the building temperature of the interior surface of the wall or roof, the temperature of the plate itself, the temperature of the exterior of the wall or roof and the temperature of the exterior air.

Tests have been conducted at the Research Laboratory of the Society with the Nicholls heat meter on certain types of wall construction, and the results obtained are in close agreement with the computed values for these same constructions.

It would be obviously impossible to determine the air to air heat transmission coefficients of every type of wall construction in use with the heat meter on account of the great amount of time involved. Hence, the method of computing the coefficients from fundamental conductivity constants must be resorted to in most cases, but the heat meter can be used to good advantage in checking the accuracy of the computed values. The Society's Laboratory will continue its investigations of the air-to-air transmission coefficients of many common types of wall constructions in order to definitely establish the accuracy of as many of the computed values as possible.

Problems involving the determination of the value of U from the conductivity constants can also be solved by what is sometimes known as the resistance method which is readily derived from the basic equation No. 5 as follows:

$$\frac{1}{U} = \frac{1}{K} + \frac{1}{K} + \frac{x}{C} = \Sigma \left[R_1 + R_2 + R_c\right]$$

TABLE 5. INTERNAL CONDUCTIVITIES OF BUILDING MATERIALS AND INSULATIONS[1]

NOTE.—The internal conductivities in this table are expressed in B.t.u. per hour, per square foot, per 1 deg. fahr., per 1 in. thickness unless otherwise stated

A. Building Materials

MATERIAL	DESCRIPTION	DENSITY (LB. PER CU. FT.)	MEAN TEMP. OF SAMPLE (DEG. FAHR.)	INTERNAL CONDUCTIVITY (C OR C_u)	AUTHORITY[14]
Asbestos	Sheet	48.3	110	0.29	Willard, Lichty & Harding
Asbestos Board	Corrugated	20.4	110	0.48	Willard, Lichty & Harding
Asbestos Wood	Asbestos and cement compressed.	123.0	86	2.70	Bureau of Standards
Asbestos Mill Bd.	Pressed Asbestos	60.5	86	0.843	Bureau of Standards
Asbestos Shingles		65.0	75	6.00[2]	Peebles, Armour Institute
Asphalt Shingles		70.0	75	6.50[2]	Peebles, Armour Institute
Brickwork	Mortar Bond and dry conditions.	132.0	100	4.00	Willard, Lichty & Harding
Brickwork	Damp or wet			5.00	Recommended by Harding & Willard[12]
Cement Mortar				8.00[7]	Willard, Lichty & Harding
Concrete	Stone 1-2-4 mix	140.0	110	8.30	Willard, Lichty & Harding
Concrete	Stone	145.0	75	6.30	Peebles, Armour Institute
Concrete	Stone 1-2-5 mix		95[3]	6.27	C.L. Norton, Boston, Mass.
Concrete	Cinder 1-2-4 mix		122	2.35	C.L. Norton, Boston, Mass.
Concrete	Cinder	110.0	75	5.20	Peebles, Armour Institute
Concrete Blocks	Stone Dry	103.6	68	4.84	Hencky
Cornell Wood Board	Ground Wood pulp (½" thick).		75	2.50[2]	Peebles, Armour Institute
Gyplap	Gypsum between layers of heavy paper (½" thick)	53.5	90	2.60[2]	Bureau of Standards
Gypsum	Building—oven dried 3 weeks.	78.0	68	2.99	Poensgen
Gypsum	Building—mixed with 15 per cent wood fiber.			2.30	Calculated[9]
Gypsum Partition Tile.	Hollow		75	1.00	Peebles, Armour Institute
Gypsum Roof Tile.	Reinforced		75	1.20	Peebles, Armour Institute
2 in. Hollow Clay Tile, ½ in. plaster both sides		120.0	110	1.00[2]	Willard, Lichty & Harding
4 in. Hollow Clay Tile, ½ in. plaster both sides		127.0	100	0.60[2]	Willard, Lichty & Harding
6 in. Hollow Clay Tile, ½ in. plaster both sides		124.3	105	0.47[2]	Willard, Lichty & Harding
2 in. Hollow Clay Tile				1.14[2]	Calculated[4]

[1]See Chapter LX, by Chas. H. Herter of the Report of the Insulation Committee, *A.S.R.E.*, Annual Meeting 1922, Revised to 1924, entitled "Heat Transmission of Insulating Materials" for a more comprehensive collection of heat transmission data relating to building and insulating materials.

[2]For thickness stated or used in construction, not per 1 in. thickness.

[3]Hot side of plate.

[4]Estimated from values reported in University of Illinois Engineering Station, Bulletin No. 102, for hollow clay tile plastered both sides, assuming the conductivity of cement plaster = 8.0 per 1 in. thickness.

[5]Calculated from 2 in. tile tests.

[6]Average of several values.

[7]Cement mortar and stucco assumed same as cement plaster.

[8]Roofing, 0.15 in. thick (1.34 lb. per sq. ft.), covered with gravel (0.83 lb. per sq. ft.), combined thickness assumed 0.25.

[9]Estimated from value of $C = 2.99$ for gypsum and $c = 1.0$ for wood.

[10]Not compressed.

[11]The conductivity of plaster varies with the composition. Note range of values from 2.32 to 8.0. The average value for plaster is probably about 5.0. On account of the comparatively high conductivity of plaster and the fact that it is seldom applied more than ¾ in. thick, this material does not appreciably effect the overall transmission of a construction, excepting in the case of thin uninsulated walls.

[12]See "Mechanical Equipment of Buildings" by Harding and Willard, page 56.

[13]Thickness of lime plaster and wood lath from back of lath to face of plaster, about ⅝ in.

[14]In addition to the conductivity values for the authorities listed, considerable work of importance pertaining to the heat transmission of various types of construction and materials has been done by the late Prof. John R. Allen and Prof. F. B. Rowley of the Engineering Experiment Station of the University of Minnesota, and Prof. A. J. Wood of the Engineering Experiment Station of Pennsylvania State College.

TABLE 5. INTERNAL CONDUCTIVITIES OF BUILDING MATERIALS AND INSULATIONS[1]—Continued

MATERIAL	DESCRIPTION	DENSITY (LB. PER CU. FT.)	MEAN TEMP. OF SAMPLE (DEG. FAHR.)	INTERNAL CONDUCTIVITY (C OR Cu)	AUTHORITY[14]
4 in. Hollow Clay Tile				0.65[2]	Calculated[4]
6 in. Hollow Clay Tile				0.50[2]	Calculated[4]
8 in. Hollow Clay Tile				0.43[2]	Estimated
12 in. Hollow Clay Tile				0.26[2]	Estimated
16 in. Hollow Clay Tile				0.185[2]	Estimated
Magnesia Board		13.5	110	0.51	Willard, Lichty & Harding
Magnesia (85 per cent) and Asbestos (15 per cent).	Rigid	19.3	86	0.508	Bureau of Standards
Plaster	Gypsum	46.2	86	2.32[11]	Bureau of Standards
Plaster	Cement			8.00[11]	Willard, Lichty & Harding
Plaster Board	Gypsum between layers of heavy paper.	62.8	70	1.41	Peebles, Armour Institute
Plaster Board			86	3.04	Bureau of Standards
Roofing[8]	Built-up bitumen and felt, gravel or slag surfaced			1.325[5]	Willard, Lichty & Harding
Roofing[8]	Built-up bitumen and felt, gravel or slag surfaced			5.30[2-5]	Willard, Lichty & Harding
Roofing	Composition or prepared		75	6.50[2]	Peebles, Armour Institute
Sawdust	Ordinary		86	1.04	Bureau of Standards
Shavings	Ordinary		86	0.707	Bureau of Standards
Sheetrock	Gypsum mixed with sawdust between layers of heavy paper (0.39 in. thick).	60.7	*90*	*3.60*[2]	Bureau of Standards
Slate			201	10.37	Lees & Chorlton
Stone	Limestone or Sandstone.			10.0	Estimated[6]
Stucco				8.00[7]	Willard, Lichty & Harding
Wood lath and plaster[13]	Lime plaster		75	2.0[2]	Peebles, Armour Institute
Woods:					
Cypress	Across grain	28.7	86	0.668	Bureau of Standards
Fir	Across grain	33.4		1.000	Willard, Lichty & Harding
Maple Flooring	Across grain	40.0	75	1.20	Peebles, Armour Institute
Maple	Across grain	44.3	86	1.103	Bureau of Standards
Mahogany	Across grain	34.3	86	0.900	Bureau of Standards
Oak		42.0	75	1.30	Peebles, Armour Institute
Virginia Pine	Across grain	34.3	86	0.958	Bureau of Standards
White Pine	Across grain	31.2	86	0.784	Bureau of Standards
Yellow Pine	Across grain			1.000	Peebles, Armour Institute
B. Insulations (Dry)					
Balsa wood	Across grain	20.0	90	0.58	Bureau of Standards
Balsa wood	Across grain	8.8	90	0.38	Bureau of Standards
Balsa wood	Across grain	7.3	90	0.33	Bureau of Standards
Balsam wool[10]	Chemically treated wood fiber.	2.2	90	0.27	Bureau of Standards
Cabots quilt[10]	Eel grass between Kraft paper.	4.6	90	0.26	Bureau of Standards
Cabots quilt[10]	Eel grass between Kraft paper.	3.4	90	0.25	Bureau of Standards
Celotex	Board form insulation made from sugar cane fiber.	13.5	70	0.33	Peebles, Armour Institute
Celotex	Board form insulation made from sugar cane fiber.	13.2	90	0.34	Bureau of Standards

[1]See footnotes 1 to 14 on p. 15.

TABLE 5. INTERNAL CONDUCTIVITIES OF BUILDING MATERIALS AND INSULATIONS[1]—Continued

B. Insulations (Dry)—(Continued)

MATERIAL	DESCRIPTION	DENSITY (LB. PER CU. FT.)	MEAN TEMP. OF SAMPLE (DEG. FAHR.)	INTERNAL CONDUCTIVITY (C OR Cu)	AUTHORITY[14]
Corkboard	Pure; no added binder.	14.0	90	0.34	Bureau of Standards
Corkboard	Pure; no added binder.	10.6	90	0.30	Bureau of Standards
Corkboard	Pure; no added binder.	7.0	90	0.27	Bureau of Standards
Corkboard	Pure; no added binder.	9.7		0.32	Willard, Lichty & Harding
Dry zero[10]	Kapok between burlap or paper.	2.0	90	0.25	Bureau of Standards
Fibrofelt[10]	Flax and rye fiber	13.6	90	0.32	Bureau of Standards
Flaxlinum[10]	Flax fiber	13.0	90	0.31	Bureau of Standards
Flaxlinum[10]	Flax fiber	14.0	70	0.32	Peebles, Armour Institute
Hairinsul[10]	75 per cent hair, 25 per cent jute	6.3	90	0.27	Bureau of Standards
Hairinsul[10]	50 per cent hair, 50 per cent jute	6.1	90	0.26	Bureau of Standards
Hair felt[10]	Felted Cattle Hair	13.0	90	0.26	Bureau of Standards
Hair felt[10]	Felted Cattle Hair	11.0	90	0.26	Bureau of Standards
Homasote Building Board (¾" thick)	Wall Board made from paper pulp.	22.9	70	0.40	Peebles, Armour Institute
Inso Board	Board form Insulation made from wheat straw.	17.0	68	0.33	Peebles, Armour Institute
Insulex or Pyrocell	Cellular Gyspum	30.0	90	1.00	Bureau of Standards
Insulex or Pyrocell	Cellular Gypsum	30.0	75	0.92	Peebles, Armour Institute
Insulex or Pyrocell	Cellular Gypsum	24.0	90	0.77	Bureau of Standards
Insulex or Pyrocell	Cellular Gypsum	24.0	75	0.737	Peebles, Armour Institute
Insulex or Pyrocell	Cellular Gypsum	*18.0*	*90*	*0.59*	*Bureau of Standards*
Insulex or Pyrocell	Cellular Gypsum	18.0	75	0.566	Peebles, Armour Institute
Insulex or Pyrocell	Cellular Gypsum	12.0	90	0.44	Bureau of Standards
Insulex or Pyrocell	Cellular Gypsum	12.0	75	0.400	Peebles, Armour Institute
Insulite	Board form insulation made from wood pulp.	16.9	90	0.34	Bureau of Standards
Insulite	Board form insulation made from wood pulp.	16.5	70	0.34	Peebles, Armour Institute
Keystone Hair[10]		11.0	75	0.25	Peebles, Armour Institute
Linofelt[10]	Flax fibers between paper.	4.9	90	0.28	Bureau of Standards
Lith	Rock wool, flax and straw pulp with binder.	14.3	90	0.40	Bureau of Standards
Lith	Rock wool, flax and straw pulp with binder.	14.5	75	0.38	Peebles, Armour Institute
Masonite	Board form insulation made from exploded wood fiber.	18.0	75	0.33	Peebles, Armour Institute
Maftex	Board form of insulation made from roots of licorice.	16.1	81	0.337	Peebles, Armour Institute
Regranulated Cork	About ¾ in. particles.	8.1	90	0.31	Bureau of Standards
Rock Cork	Rock Wool and Waterproof binder.	16.7	86	0.37	Bureau of Standards.
Rock Wool[10]	Fibrous material, made from rock. Also made in sheet form, felted and confined with netting.	10.0	90	0.27	Bureau of Standards

[1]See footnotes 1 to 14 on p. 15.

TABLE 5. INTERNAL CONDUCTIVITIES OF BUILDING MATERIALS AND INSULATIONS[1]—Continued

B. Insulations (Dry)—(Continued)

MATERIAL	DESCRIPTION	DENSITY (LB. PER CU. FT.)	MEAN TEMP. OF SAMPLE (DEG. FAHR.)	INTERNAL CONDUCTIVITY (C OR C_u)	AUTHORITY[14]
Thermofelt[10]	Jute and asbestos fibers, felted.	10.0	90	0.37	Bureau of Standards
Thermofelt[10]	Hair and asbestos fibers, felted.	7.8	90	0.28	Bureau of Standards
Thermofill	Dry, Fluffy, Flaked Gypsum.	34.0	90	0.60	Bureau of Standards
Thermofill	Dry, Fluffy, Flaked Gypsum.	26.0	90	0.52	Bureau of Standards
Thermofill	Dry, Fluffy, Flaked Gypsum.	24.0*	75	0.475	Peebles, Armour Institute
Thermofill	Dry, Fluffy, Flaked Gypsum.	18.0†	75	0.34	Peebles, Armour Institute
Thermasote Insulating Board.	Board form Insulation made from wood pulp.	20.8	70	0.374	Peebles, Armour Institute

*Weight used in walls.
†Weight used in ceilings.

$$\text{or } U = \frac{1}{\Sigma\,[R_1 + R_2 + R_c]}$$

The internal resistance of a material is equal to the reciprocal of its so-called internal conductivity (C) multiplied by its thickness and is represented by the fraction $\frac{x}{C}$, or $\frac{1}{C_u}$, in the case of materials for which the conductivity (or conductance) is given in terms of the construction or thickness stated. For example, the internal resistance of 13 in. of brickwork on the basis of value of C of 5.0 is $\frac{13}{5}$ or 2.6. The internal resistance of 2 in. hollow clay tile based on the value of C_u of 1.14 is $\frac{1}{1.14}$ or 0.877.

In the resistance method, the sum of the internal resistances of all the materials entering into the construction, is added to the sum of the surface resistances, which are the reciprocals of the surface coefficients or $\frac{1}{K}$. The resistance of a surface in still air, based on the average value of K_1 or 1.34 is $\frac{1}{1.34}$ or 0.746. The resistance of an outside surface exposed to the wind, based on the average value of K_2 or 4.02 (3×1.34) is $\frac{1}{4.02}$ or 0.249. The computed value of U obtained by the resistance method is obtained by taking the reciprocal of the sum of the internal and surface resistances of the construction. The solution of Example V in Fig. 3, by means of the resistance method is given in the accompanying tabulation:

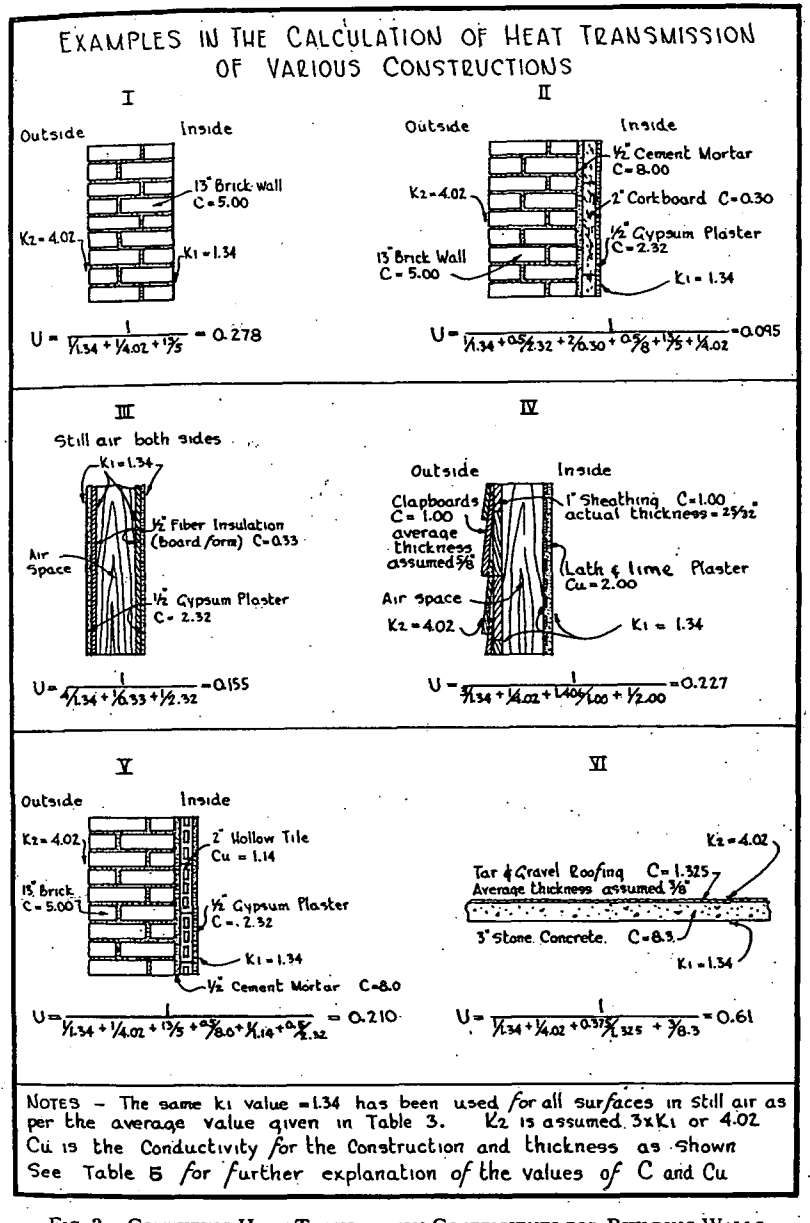


FIG. 3. COMPUTING HEAT TRANSMISSION COEFFICIENTS FOR BUILDING WALLS

MATERIAL	THICKNESS INCHES	INTERNAL CONDUCTIVITY (C or C_u)	SURFACE COEFFICIENTS (K_1 or K_2)	INTERNAL RESISTANCE	SURFACE RESISTANCE
Brickwork	13	5.0 (C)	4.02 (K_2)	2.600	0.249
Cement Mortar	½	8.0 (C)	.....	0.063	.....
Hollow Clay Tile	2	1.14 (C_u)	.....	0.877	.....
Plaster (gypsum)	½	2.32 (C)	1.34 (K_1)	0.215	0.746
				3.755	0.995
					3.755
Total resistance (R)					4.750

$$U = \frac{1}{R} = \frac{1}{4.750} = 0.210$$ B.t.u. per hour per square foot per 1 deg. fahr. difference in temperature between the air on the two sides of the wall.

TABLE 6. FACTORS TO BE USED IN DETERMINING VALUES OF OUTSIDE SURFACE COEFFICIENTS (K_2) UNDER MOVING AIR CONDITIONS

IN EACH CASE, THE MOVING AIR FACTOR IS BASED ON STILL AIR COEFFICIENT (K_1) FOR *same* MATERIAL. FOR CONDITIONS WHERE WIND VELOCITY IS NOT KNOWN USE THE FACTOR (3) OR TAKE K_2 AS $3K_1$ FOR SAME MATERIAL.

Wind Velocity in Miles per Hour	Multipliers of K_1*		
	Brickwork	Wood	Average
5	2.38	2.19	2.28
10	3.20	2.71	2.96
15	3.76	2.95	3.36**
20	4.22	3.02	3.62
	Additional Values—Smooth Surface		
10	.....	2.20	.....
20	.....	2.60	.....
Above 20	.....	3.00	.....

*Taken from Engineering Experiment Station Bulletin No. 102, of the University of Illinois. Additional values from Engineering Experiment Station, Pennsylvania State College, reported by Professor Wood. Tests at Pennsylvania State College indicate character of surface, rough or smooth, more important than material of surface.

**This is usually taken as 3 even.

The thicknesses upon which the coefficients in Tables 7 to 13, inclusive, are based, are as follows:

Brick veneer	4 in.
Plaster and metal lath	¾ in.
Plaster [on wood lath, plasterboard, fiber insulation (board form), or corkboard]	½ in.
Slate (Roofing)	½ in.
Stucco on wire mesh reinforcing	1 in.
Tar and gravel or slag surfaced built-up roofing	⅜ in.
Wood shingles (average thickness)	⅝ in.
Wood siding or clapboard (average thickness)	⅝ in.
1-in. Lumber (S-2-S)	$\frac{25}{32}$ in.
1½-in. Lumber (S-2-S)	$1\frac{9}{16}$ in.
2-in. Lumber (S-2-S)	$1\frac{5}{8}$ in.
2½-in. Lumber (S-2-S)	$2\frac{1}{8}$ in.
3-in. Lumber (S-2-S)	$2\frac{5}{8}$ in.
4-in. Lumber (S-2-S)	$3\frac{5}{8}$ in.
Finish flooring (Maple or Oak)	$\frac{13}{16}$ in.

Note that actual thicknesses of lumber are used in the computations rather than nominal thicknesses.

On account of the fact that the internal resistances of metal and single

thicknesses of building paper[4] and roofing felt are very small, these resistances were neglected in the calculations, in accordance with standard practice. The computations for wood shingle roofs applied over wood stripping are based on 1 by 4 in. wood strips, spaced 2 in. apart. Since no reliable figures are available concerning the conductivity of Spanish and French clay roofing tile, of which there are many varieties, the figures for such types of roofs were taken the same as for slate roofs, as it is probable that the values of U for these two types of roofs will compare favorably.

The coefficients of transmission of the pitched roofs in Table 12-A apply where the roof is over a heated attic or top floor, such that the heat passes directly through the roof structure including whatever finish, if any, is applied to the underside of the roof rafters. By a heated attic is meant an attic to which heat is supplied directly from the furnace or boiler by means of radiators, hot-air registers, or other means.

If the attic is unheated, the roof structure and ceiling of the top floor must both be taken into consideration and the combined coefficient of transmission determined. The formula for calculating the combined coefficient of transmission of a top-floor ceiling, unheated attic space and pitched roof, *per square foot of roof area*, is as follows:

$$U = \frac{U_r \times U_{ce}}{n \times U_r + U_{ce}}$$

where

U_r = coefficient of transmission of the roof. (From Table 12-A, Pitched Roofs).

U_{ce} = coefficient of transmission of the ceiling. (From Table 10).

n = the ratio of the area of the roof to the area of the ceiling.

The following example will illustrate the use of this formula: Determine the combined coefficient of transmission of a roof constructed of wood shingles applied over wood strips on rafters, an unheated attic, and a wood lath and plaster ceiling, based on a roof having a ⅓ pitch, for which the value of n is 1.2 (Roof No. 251a).

$U_r = 0.483$ (Roof No. 238-a, Table 12-A)
$U_{ce} = 0.502$ (Ceiling No. 167-a, Table 10-A)

Substituting these values in the preceding formula:

$$U = \frac{0.483 \times 0.502}{1.2 \times 0.483 + 0.502}$$

$= 0.224$ B.t.u. per hour, per square foot of roof area per 1 deg. fahr. difference in temperature between the air near the underside of the ceiling and the outside air.

Combined coefficients for many common types of pitched roofs and top-floor ceilings for unheated attics are given in Table 12-B.

[4]Building paper is used because of its value as a wind stop only.

TABLE 7-A. COEFFICIENTS OF TRANSMISSION (*U*) OF VARIOUS TYPES OF MASONRY WALL CONSTRUCTION

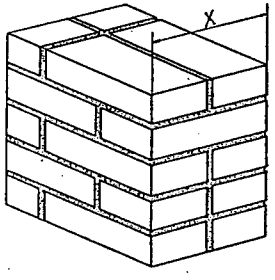
Note.—These coefficients are expressed in B.t.u. per hour per square foot per 1 deg. fahr. difference in temperature between the air on the two sides and are based on an outside wind exposure of 15 miles per hour.

SOLID BRICK WALLS †

The values of U in this Table are based on the following Internal Conductivities (C) which are expressed in B.t.u. per Hr. per Sq. Ft. per 1° F

Brick	5.00	per 1"
Cement Mortar	8.00	per 1"
Plaster Board	3.04	per 1"
Plaster (Gypsum)	2.32	per 1"
Wood Lath & Plaster	2.00	as applied
Cork board	0.30	per 1"
Fiber Insulation (Board form)	0.33	per 1"
Cellular Gypsum (18#)	0.59	per 1"
Flaked Gypsum, Dry (26#)	0.52	per 1"
Hollow Tile 2" = 1.14	4" = 0.65	

Y = Thickness of Insulation where specified



Wall Number	Interior Construction	Y	Thickness of Brick – X			
			9"	13"	18"	24"
			a	b	c	d
1	Plain Walls – No Interior Finish		0.358	0.278	0.218	0.173
2	½" Plaster on Brick		0.332	0.263	0.208	0.166
3	¾" Plaster on Metal Lath – Furred		0.216	0.185	0.156	0.131
4	½" Plaster on Wood Lath – Furred		0.209	0.179	0.152	0.128
5	½" Plaster on ⅜" Plaster Board – Furred		0.215	0.184	0.155	0.131
6	½" Plaster on Wood Lath on 2" Furring Strips – Cellular Gypsum Fill	1⅝"*	0.165	0.146	0.128	0.111
7	½" Plaster on Wood Lath on 2" Furring Strips – Flaked Gypsum Fill	1⅝"*	0.156	0.139	0.122	0.106
8	½" Plaster on Fibre Insulation – (Board form) Furred	½"	0.166	0.147	0.128	0.111
9		1"	0.133	0.120	0.107	0.095
10	½" Plaster on Cork board Set in ½" Cement Mortar	1½"	0.124	0.113	0.102	0.090
11		2"	0.103	0.095	0.087	0.079
11-A	½" Plaster on 2" Hollow Tile (½" Cement Mortar between Tile and Brick)		0.252	0.210	0.174	0.144
11-B	½" Plaster on 4" Hollow Tile (½" Cement Mortar between Tile and Brick)		0.217	0.185	0.156	0.131

*Based on 1⅝ in., the actual thickness of 2 in. furring strips.

†The coefficients on this page can also be used with sufficient accuracy for the Ideal Rolok-Bak Wall.

Note.—The coefficient used for plasterboard is 3.04 per inch thickness—recent data indicate values as low as 1.30 for this material.

Note.—The coefficient used for cellular gypsum, 0.59 is for 18 lb. weight—weights as low as 12 lb. may be used.

TABLE 7-B. COEFFICIENTS OF TRANSMISSION (*U*) OF VARIOUS TYPES OF MASONRY WALL CONSTRUCTION

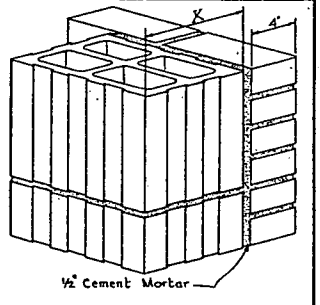
Note.—These coefficients are expressed in B.t.u. per hour per square foot per 1 deg. fahr. difference in temperature between the air on the two sides and are based on an outside wind exposure of 15 miles per hour.

BRICK VENEER ON HOLLOW TILE WALLS

The values of U in this Table are based on the following Internal Conductivities (C) which are expressed in B.t.u. per Hr. per Sq. Ft. per 1° F

Hollow Tile 4"-0.65	6"-0.50	8"-0.43 12"-0.26
Brick	5.00	per 1"
Cement Mortar	8.00	per 1"
Plaster Board	3.04	per 1"
Plaster (Gypsum)	2.32	per 1"
Wood Lath & Plaster	2.00	as applied
Cork board	0.30	per 1"
Fiber Insulation (Board form)	0.33	per 1"
Cellular Gypsum (18#)	0.59	per 1"
Flaked Gypsum, Dry (26#)	0.52	per 1"

Y = Thickness of Insulation where specified



Wall Number	Interior Construction	Y	Thickness of Hollow Tile – X			
			4"	6"	8"	12"
			a	b	c	d
12	Plain Walls – No Interior Finish		0.294	0.260	0.240	0.175
13	½" Plaster on Hollow Tile		0.277	0.246	0.228	0.169
14	¾" Plaster on Metal Lath – Furred		0.192	0.176	0.167	0.133
15	½" Plaster on Wood Lath – Furred		0.186	0.171	0.162	0.130
16	½" Plaster on ⅜" Plaster Board – Furred		0.191	0.176	0.166	0.133
17	½" Plaster on Wood Lath on 2" Furring Strips – Cellular Gypsum Fill	1⅝"*	0.151	0.141	0.135	0.112
18	½" Plaster on Wood Lath on 2" Furring Strips – Flaked Gypsum Fill	1⅝"*	0.142	0.134	0.128	0.107
19	½" Plaster on Fiber Insulation – (Board form) Furred	½"	0.151	0.141	0.135	0.112
20		1"	0.123	0.117	0.112	0.096
21	½" Plaster on Cork board Set in ½" Cement Mortar	1½"	0.115	0.109	0.105	0.091
22		2"	0.097	0.092	0.090	0.079

*Based on 1⅝ in., the actual thickness of 2 in. furring strips.

Note.—The coefficient used for plasterboard is 3.04 per inch thickness—recent data indicate values as low as 1.30 for this material.

Note.—The coefficient used for cellular gypsum, 0.59 is for 18 lb. weight—weights as low as 12 lb. may be used.

TABLE 7-C. COEFFICIENTS OF TRANSMISSION (*U*) OF VARIOUS TYPES OF MASONRY WALL CONSTRUCTION

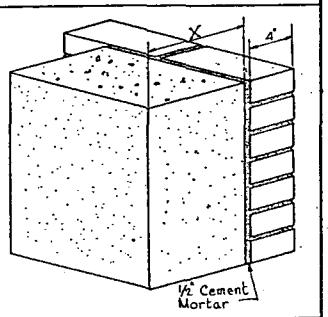
Note.—These coefficients are expressed in B.t.u. per hour per square foot per 1 deg. fahr. difference in temperature between the air on the two sides and are based on an outside wind exposure of 15 miles per hour.

BRICK VENEER ON CONCRETE WALLS

The values of U in this Table are based on the following Internal Conductivities (C) which are expressed in B.t.u. per Hr. per Sq. Ft. per 1° F

Concrete (Stone 1:2:4 mix)	8.30	per 1"
Brick	5.00	per 1"
Cement Mortar	8.00	per 1"
Plaster Board	3.04	per 1"
Plaster (Gypsum)	2.32	per 1"
Wood Lath & Plaster	2.00	as applied
Cork board	0.30	per 1"
Fiber Insulation (Board form)	0.33	per 1"
Cellular Gypsum (18#)	0.59	per 1"
Flaked Gypsum, Dry (26#)	0.52	per 1"

Y-Thickness of Insulation where specified



Wall Number	Interior Construction	Y	Thickness of Concrete -X				
			6"	8"	10"	12"	16"
			a	b	c	d	e
23	Plain Walls - No Interior Finish		0.387	0.355	0.327	0.303	0.264
24	½" Plaster on Concrete		0.358	0.330	0.305	0.285	0.250
25	¾" Plaster on Metal Lath - Furred		0.228	0.216	0.205	0.195	0.179
26	½" Plaster on Wood Lath - Furred		0.219	0.208	0.198	0.189	0.173
27	½" Plaster on ⅜" Plaster Board - Furred		0.226	0.215	0.204	0.195	0.178
28	½" Plaster on Wood Lath on 2" Furring Strips - Cellular Gypsum Fill	1⅝"*	0.172	0.165	0.158	0.152	0.142
29	½" Plaster on Wood Lath on 2" Furring Strips - Flaked Gypsum Fill	1⅝"*	0.161	0.155	0.150	0.145	0.135
30	½" Plaster on Fiber Insulation - (Board form) Furred	½"	0.172	0.165	0.159	0.153	0.144
31		1"	0.137	0.132	0.128	0.124	0.117
32	½" Plaster on Cork board set in ½" Cement Mortar	1½"	0.127	0.123	0.120	0.116	0.110
33		2"	0.105	0.102	0.100	0.098	0.093

*Based on 1⅝ in., the actual thickness of 2 in. furring strips.

Note.—The coefficient used for plasterboard is 3.04 per inch thickness—recent data indicate values as low as 1.30 for this material.

Note.—The coefficient used for cellular gypsum, 0.59 is for 18 lb. weight—weights as low as 12 lb. may be used.

TABLE 7-D. COEFFICIENTS OF TRANSMISSION (*U*) OF VARIOUS TYPES OF MASONRY WALL CONSTRUCTION

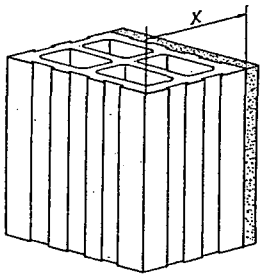
Note.—These coefficients are expressed in B.t.u. per hour per square foot per 1 deg. fahr. difference in temperature between the air on the two sides and are based on an outside wind exposure of 15 miles per hour.

HOLLOW TILE WALLS WITH STUCCO EXTERIOR FINISH †

The values of U in this Table are based on the following Internal Conductivities (C) which are expressed in B.t.u. per Hr. per Sq. Ft. per 1° F

Stucco	8.00	per 1"
Hollow Tile 6"-0.50 8"-0.43 12"-0.26 16"-0.185		
Cement Mortar	8.00	per 1"
Plaster Board	3.04	per 1"
Plaster (Gypsum)	2.32	per 1"
Wood Lath & Plaster	2.00	as applied
Cork board	0.30	per 1"
Fiber Insulation (Board form)	0.33	per 1"
Cellular Gypsum (18#)	0.59	per 1"
Flaked Gypsum, Dry (26#)	0.52	per 1"

Y-Thickness of Insulation where specified



Wall Number	Interior Construction	Y	Thickness of Hollow Tile -X			
			6"	8"	12"	16"
			a	b	c	d
34	Plain Walls - No Interior Finish		0.320	0.291	0.201	0.153
35	½" Plaster on Hollow Tile		0.299	0.273	0.193	0.149
36	¾" Plaster on Metal Lath - Furred		0.203	0.190	0.147	0.120
37	½" Plaster on Wood Lath - Furred		0.196	0.184	0.144	0.117
38	½" Plaster on ⅜" Plaster Board - Furred		0.202	0.190	0.147	0.120
39	½" Plaster on Wood Lath on 2" Furring Strips - Cellular Gypsum Fill	1⅝"*	0.157	0.149	0.122	0.102
40	½" Plaster on Wood Lath on 2" Furring Strips - Flaked Gypsum Fill	1⅝"*	0.148	0.142	0.116	0.099
41	½" Plaster on Fiber Insulation - (Board form) Furred	½"	0.158	0.150	0.122	0.103
42		1"	0.127	0.122	0.103	0.089
43	½" Plaster on Cork board set in ½" Cement Mortar	1½"	0.119	0.115	0.098	0.085
44		2"	0.099	0.096	0.084	0.074

*Based on 1⅝ in., the actual thickness of 2 in. furring strips.

†Figures on this page can be used with sufficient accuracy for hollow tile walls without stucco finish.

Note.—The coefficient used for plasterboard is 3.04 per inch thickness—recent data indicate values as low as 1.30 for this material.

Note.—The coefficient used for cellular gypsum, 0.59 is for 18 lb. weight—weights as low as 12 lb. may be used.

Table 7-E. Coefficients of Transmission (*U*) of Various Types of Masonry Wall Construction

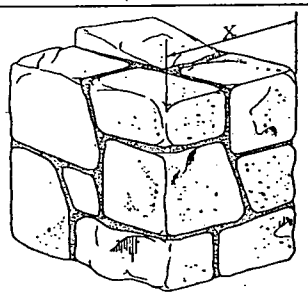
Note.—These coefficients are expressed in B.t.u. per hour per square foot per 1 deg. fahr. difference in temperature between the air on the two sides and are based on an outside wind exposure of 15 miles per hour.

Limestone or Sandstone Walls

The values of U in this Table are based on the following Internal Conductivities (C) which are expressed in B.t.u. per Hr. per Sq.ft. per 1°F

Stone	10.00	per 1"
Cement Mortar	8.00	per 1"
Plaster Board	3.04	per 1"
Plaster (Gypsum)	2.32	per 1"
Wood Lath & Plaster	2.00	as applied
Cork board	0.30	per 1"
Fiber Insulation (Board form)	0.33	per 1"
Cellular Gypsum (18#)	0.59	per 1"
Flaked Gypsum, Dry (22#)	0.52	per 1"

Y = Thickness of Insulation where specified



Wall Number	Interior Construction	Y	Thickness of Stone - X					
			8"	10"	12"	16"	20"	24"
			a	b	c	d	e	f
45	Plain Walls — No Interior Finish		0.556	0.502	0.457	0.339	0.334	0.295
46	½" Plaster on Stone		0.497	0.452	0.415	0.356	0.311	0.277
47	¾" Plaster on Metal Lath — Furred		0.277	0.262	0.249	0.227	0.208	0.192
48	½" Plaster on Wood Lath - Furred		0.264	0.251	0.239	0.218	0.200	0.185
49	½" Plaster on ⅜" Plaster Board - Furred		0.275	0.261	0.248	0.226	0.207	0.191
50	½" Plaster on Wood Lath on 2" Furring Strips — Cellular Gypsum Fill	1⅝"*	0.198	0.191	0.184	0.171	0.160	0.150
51	½" Plaster on Wood Lath on 2" Furring Strips — Flaked Gypsum Fill	1⅝"*	0.185	0.178	0.172	0.161	0.151	0.143
52	½" Plaster on Fiber Insulation — (Board form) Furred	½"	0.199	0.192	0.184	0.172	0.161	0.151
53		1"	0.153	0.149	0.144	0.136	0.129	0.123
54	½" Plaster on Corkboard set in ½" Cement Mortar	1½"	0.141	0.138	0.134	0.127	0.121	0.115
55		2"	0.114	0.112	0.109	0.105	0.101	0.098

*Based on 1⅝ in., the actual thickness of 2 in. furring strips.

Note.—The coefficient used for plasterboard is 3.04 per inch thickness—recent data indicate values as low as 1.30 for this material.

Note.—The coefficient used for cellular gypsum, 0.59 is for 18 lb. weight—weights as low as 12 lb. may be used.

Table 7-F. Coefficients of Transmission (*U*) of Various Types of Masonry Wall Construction

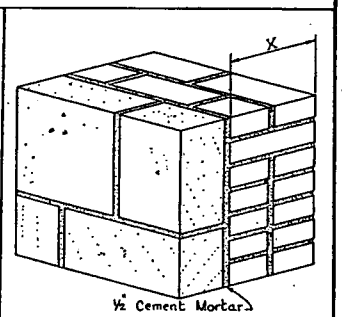
Note.—These coefficients are expressed in B.t.u. per hour per square foot per 1 deg. fahr. difference in temperature between the air on the two sides and are based on an outside wind exposure of 15 miles per hour.

4" Cut Stone Veneer on Brick Walls

The values of U in this Table are based on the following Internal Conductivities (C) which are expressed in B.t.u. per Hr. per Sq.ft. per 1°F

Stone	10.00	per 1"
Brick	5.00	per 1"
Cement Mortar	8.00	per 1"
Plaster Board	3.04	per 1"
Plaster (Gypsum)	2.32	per 1"
Wood Lath & Plaster	2.00	as applied
Cork board	0.30	per 1"
Fiber Insulation (Board form)	0.33	per 1"
Cellular Gypsum (18#)	0.59	per 1"
Flaked Gypsum, Dry (22#)	0.52	per 1"

Y = Thickness of Insulation where specified



Wall Number	Interior Construction	Y	Thickness of Brick - X			
			9"	13"	18"	24"
			a	b	c	d
56	Plain Walls — No Interior Finish		0.281	0.246	0.198	0.160
57	½" Plaster on Brick		0.280	0.234	0.190	0.155
58	¾" Plaster on Metal Lath - Furred		0.193	0.170	0.146	0.124
59	½" Plaster on Wood Lath - Furred		0.187	0.165	0.142	0.121
60	½" Plaster on ⅜" Plaster Board - Furred		0.193	0.170	0.145	0.125
61	½" Plaster on Wood Lath on 2" Furring Strips - Cellular Gypsum Fill	1⅝"*	0.151	0.137	0.120	0.105
62	½" Plaster on Wood Lath on 2" Furring Strips — Flaked Gypsum Fill	1⅝"*	0.143	0.130	0.115	0.101
63	½" Plaster on Fiber Insulation — (Board form) Furred	½"	0.152	0.137	0.121	0.105
64		1"	0.124	0.114	0.102	0.091
65	½" Plaster on Corkboard set in ½" Cement Mortar	1½"	0.116	0.107	0.097	0.087
66		2"	0.097	0.091	0.083	0.076

*Based on 1⅝ in., the actual thickness of 2 in. furring strips.

Note.—The coefficient used for plasterboard is 3.04 per inch thickness—recent data indicate values as low as 1.30 for this material.

Note.—The coefficient used for cellular gypsum, 0.59 is for 18 lb. weight—weights as low as 12 lb. may be used.

Table 7-G. Coefficients of Transmission (U) of Various Types of Masonry Wall Construction

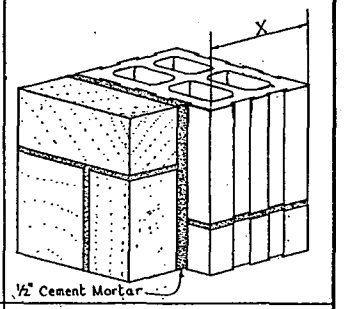
Note.—These coefficients are expressed in B.t.u. per hour per square foot per 1 deg. fahr. difference in temperature between the air on the two sides and are based on an outside wind exposure of 15 miles per hour.

4" Cut Stone Veneer on Hollow Tile Walls

The values of U in this Table are based on the following Internal Conductivities (C) which are expressed in B.t.u. per Hr. per Sq.Ft. per 1° F

Hollow Tile	4"-0.65 6"-0.50 8"-0.43 12"-0.26	
Stone	10.00	per 1"
Cement Mortar	8.00	per 1"
Plaster Board	3.04	per 1"
Plaster (Gypsum)	2.32	per 1"
Wood Lath & Plaster	2.00	as applied
Cork board	0.30	per 1"
Fiber Insulation (Board/form)	0.33	per 1"
Cellular Gypsum* (18#)	0.59	per 1"
Flaked Gypsum, Dry (26#)	0.52	per 1"

Y Thickness of Insulation where specified



Wall Number	Interior Construction	Y	Thickness of Hollow Tile - X			
			6"	8"	12"	16"
			a	b	c	d
67	Plain Walls - No Interior Finish		0.289	0.265	0.189	0.146
68	½" Plaster on Hollow Tile		0.272	0.250	0.184	0.141
69	¾" Plaster on Metal Lath - Furred		0.190	0.179	0.140	0.115
70	½" Plaster on Wood Lath - Furred		0.183	0.173	0.137	0.113
71	½" Plaster on ⅜" Plaster Board - Furred		0.189	0.178	0.140	0.115
72	½" Plaster on Wood Lath on 2" Furring Strips - Cellular Gypsum Fill	1⅝"*	0.149	0.142	0.117	0.099
73	½" Plaster on Wood Lath on 2" Furring Strips - Flaked Gypsum Fill	1⅝"*	0.141	0.135	0.112	0.095
74	½" Plaster on Fiber Insulation - (Board form) Furred	½"	0.150	0.143	0.117	0.099
75		1"	0.122	0.117	0.099	0.086
76	½" Plaster on Corkboard set in ½" Cement Mortar	1½"	0.114	0.110	0.094	0.082
77		2"	0.096	0.093	0.081	0.072

*Based on 1⅝ in., the actual thickness of 2 in. furring strips.

Note.—The coefficient used for plasterboard is 3.04 per inch thickness—recent data indicate values as low as 1.30 for this material.

Note.—The coefficient used for cellular gypsum, 0.59 is for 18 lb. weight—weights as low as 12 lb. may be used.

Table 7-H. Coefficients of Transmission (U) of Various Types of Masonry Wall Construction

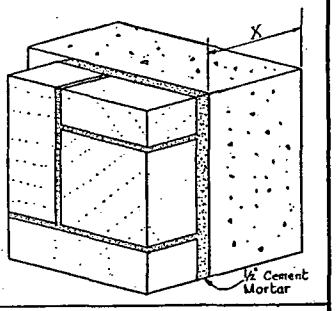
Note.—These coefficients are expressed in B.t.u. per hour per square foot per 1 deg. fahr. difference in temperature between the air on the two sides and are based on an outside wind exposure of 15 miles per hour.

4" Cut Stone Veneer on Concrete Walls

The values of U in this Table are based on the following Internal Conductivities (C) which are expressed in B.t.u. per Hr. per Sq.Ft. per 1° F

Stone	10.00	per 1"
Concrete (Stone 1:2:4 mix)	8.30	per 1"
Cement Mortar	8.00	per 1"
Plaster Board	3.04	per 1"
Plaster (Gypsum)	2.32	per 1"
Wood Lath & Plaster	2.00	as applied
Cork board	0.30	per 1"
Fiber Insulation (Board/form)	0.33	per 1"
Cellular Gypsum (18#)	0.59	per 1"
Flaked Gypsum, Dry (26#)	0.52	per 1"

Y-Thickness of Insulation where specified



Wall Number	Interior Construction	Y	Thickness of Concrete - X				
			6"	8"	10"	12"	16"
			a	b	c	d	e
78	Plain Walls - No Interior Finish		0.459	0.413	0.377	0.345	0.296
79	½" Plaster on Concrete		0.418	0.380	0.348	0.321	0.279
80	¾" Plaster on Metal Lath - Furred		0.251	0.236	0.224	0.212	0.193
81	½" Plaster on Wood Lath - Furred		0.240	0.227	0.215	0.204	0.186
82	½" Plaster on ⅜" Plaster Board - Furred		0.249	0.235	0.223	0.211	0.192
83	½" Plaster on Wood Lath on 2" Furring Strips - Cellular Gypsum Fill	1⅝"*	0.184	0.176	0.169	0.163	0.151
84	½" Plaster on Wood Lath on 2" Furring Strips - Flaked Gypsum Fill	1⅝"*	0.172	0.166	0.159	0.153	0.143
85	½" Plaster on Fiber Insulation - (Board form) Furred	½"	0.185	0.177	0.170	0.163	0.151
86		1"	0.145	0.140	0.135	0.131	0.123
87	½" Plaster on Corkboard set in ½" Cement Mortar	1½"	0.134	0.130	0.126	0.122	0.116
88		2"	0.110	0.107	0.104	0.102	0.097

*Based on 1⅝ in., the actual thickness of 2 in. furring strips.

Note.—The coefficient used for plasterboard is 3.04 per inch thickness—recent data indicate values as low as 1.30 for this material.

Note.—The coefficient used for cellular gypsum, 0.59 is for 18 lb. weight—weights as low as 12 lb. may be used.

Table 7-I. Coefficients of Transmission (*U*) of Various Types of Masonry Wall Construction

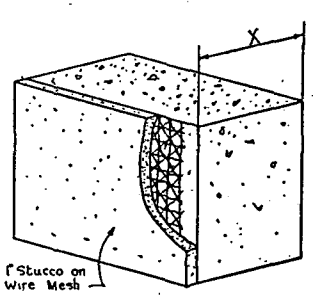
Note.—These coefficients are expressed in B.t.u. per hour per square foot per 1 deg. fahr. difference in temperature between the air on the two sides and are based on an outside wind exposure of 15 miles per hour.

Concrete Walls with Stucco as Exterior Finish

The values of U in this Table are based on the following Internal Conductivities (C) which are expressed in B.t.u. per Hr. per Sq. Ft. per 1°F

Stucco	8.00	per 1"
Concrete (Stone 1:2:4 mix)	8.30	per 1"
Plaster Board	3.04	per 1"
Plaster (Gypsum)	2.32	per 1"
Wood Lath & Plaster	2.00	as applied
Cork board	0.30	per 1"
Fiber Insulation (Board form)	0.33	per 1"
Cellular Gypsum (18#)	0.59	per 1"
Flaked Gypsum, Dry (26#)	0.52	per 1"

Y = Thickness of Insulation where specified



Wall Number	Interior Construction	Y	Thickness of Concrete - X					
			6"	8"	10"	12"	16"	20"
			a	b	c	d	e	f
89	Plain Walls - No Interior Finish		0.544	0.481	0.431	0.391	0.329	0.284
90	½ Plaster on Concrete		0.486	0.437	0.395	0.361	0.308	0.268
91	¾ Plaster on Metal Lath - Furred		0.273	0.257	0.242	0.229	0.206	0.187
92	½ Plaster on Wood Lath - Furred		0.261	0.246	0.232	0.220	0.199	0.181
93	½ Plaster on ⅜ Plaster Board - Furred		0.272	0.256	0.241	0.228	0.205	0.187
94	½ Plaster on Wood Lath on 2" Furring Strips - Cellular Gypsum Fill	1⅝*	0.196	0.188	0.179	0.172	0.159	0.148
95	½ Plaster on Wood Lath on 2" Furring Strips - Flaked Gypsum Fill	1⅞*	0.183	0.175	0.168	0.162	0.150	0.140
96	½ Plaster on Fiber Insulation - (Board form) Furred	½"	0.197	0.189	0.180	0.173	0.160	0.148
97		1"	0.152	0.147	0.142	0.137	0.128	0.121
98	½ Plaster on Corkboard set in ½" Cement Mortar	1½"	0.141	0.136	0.132	0.127	0.120	0.114
99		2"	0.114	0.111	0.108	0.105	0.100	0.096

*Based on 1⅝ in., the actual thickness of 2 in. furring strips.

Note.—The coefficient used for plasterboard is 3.04 per inch thickness—recent data indicate values as low as 1.30 for this material.

Note.—The coefficient used for cellular gypsum, 0.59 is for 18 lb. weight—weights as low as 12 lb. may be used.

Table 7-J. Coefficients of Transmission (*U*) of Various Types of Masonry Wall Construction

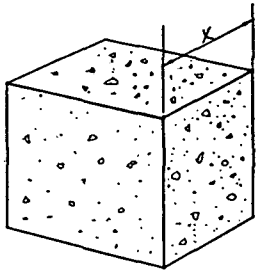
Note.—These coefficients are expressed in B.t.u. per hour per square foot per 1 deg. fahr. difference in temperature between the air on the two sides and are based on an outside wind exposure of 15 miles per hour.

Concrete Walls with No Exterior Finish

The values of U in this Table are based on the following Internal Conductivities (C) which are expressed in B.t.u. per Hr. per Sq. Ft. per 1°F

Concrete (Stone 1:2:4 mix)	8.30	per 1"
Plaster Board	3.04	per 1"
Plaster (Gypsum)	2.32	per 1"
Wood Lath & Plaster	2.00	as applied
Cork board	0.30	per 1"
Fiber Insulation (Board form)	0.33	per 1"
Cellular Gypsum (18#)	0.59	per 1"
Flaked Gypsum, Dry (26#)	0.52	per 1"

Y = Thickness of Insulation where specified



Wall Number	Interior Construction	Y	Thickness of Concrete - X					
			6"	8"	10"	12"	16"	20"
			a	b	c	d	e	f
89-A	Plain Walls - No Interior Finish		0.583	0.512	0.455	0.411	0.343	0.294
90-A	½" Plaster on Concrete		0.518	0.461	0.416	0.378	0.320	0.277
91-A	¾" Plaster on Metal Lath - Furred		0.283	0.265	0.250	0.236	0.211	0.192
92-A	½" Plaster on Wood Lath - Furred		0.270	0.254	0.239	0.226	0.204	0.185
93-A	½" Plaster on ⅜ Plaster Board - Furred		0.282	0.265	0.248	0.235	0.211	0.191
94-A	½" Plaster on Wood Lath on 2" Furring Strips - Cellular Gypsum Fill	1⅝*	0.202	0.192	0.183	0.176	0.162	0.151
95-A	½" Plaster on Wood Lath on 2" Furring Strips - Flaked Gypsum Fill	1⅞*	0.187	0.179	0.172	0.165	0.153	0.143
96-A	½" Plaster on Fiber Insulation - (Board form) Furred	½"	0.203	0.194	0.184	0.177	0.163	0.151
97-A		1"	0.155	0.150	0.145	0.139	0.130	0.123
98-A	½" Plaster on Corkboard set in ½" Cement Mortar	1½"	0.142	0.138	0.134	0.131	0.122	0.116
99-A		2"	0.116	0.113	0.109	0.106	0.101	0.097

*Based on 1⅝ in., the actual thickness of 2 in. furring strips.

Note.—The coefficient used for plasterboard is 3.04 per inch thickness—recent data indicate values as low as 1.30 for this material.

Note.—The coefficient used for cellular gypsum, 0.59 is for 18 lb. weight—weights as low as 12 lb. may be used.

TABLE 7-K. COEFFICIENTS OF TRANSMISSION (*U*) OF VARIOUS TYPES OF MASONRY WALL CONSTRUCTION

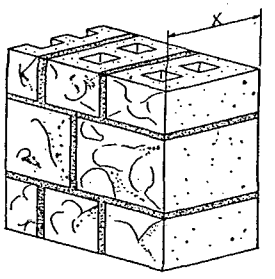
Note.—These coefficients are expressed in B.t.u. per hour per square foot per 1 deg. fahr. difference in temperature between the air on the two sides and are based on an outside wind exposure of 15 miles per hour.

CONCRETE BLOCK WALLS †

The values of U in this Table are based on the following Internal Conductivities (C) which are expressed in B.t.u. per Hr. per Sq.Ft. per 1° F

Concrete Blocks	4.84‡	per 1"
Cement Mortar	8.00	per 1"
Plaster Board	3.04	per 1"
Plaster (Gypsum)	2.32	per 1"
Wood Lath & Plaster	2.00	as applied
Cork board	0.30	per 1"
Fiber Insulation (Board form)	0.33	per 1"
Cellular Gypsum (18#)	0.59	per 1"
Powdered Gypsum (26#) Flaked Gypsum, Dry (26#)	0.52	per 1"

Y = Thickness of Insulation where Specified



Wall Number	Interior Construction	Y	Thickness of Concrete Blocks - X			
			6"	8"	10"	12"
			a	b	c	d
100	Plain Walls - No Interior Finish		0.446	0.377	0.327	0.287
101	½" Plaster on Concrete Blocks		0.408	0.348	0.305	0.271
102	¾" Plaster on Metal Lath - Furred		0.247	0.224	0.205	0.189
103	½" Plaster on Wood Lath - Furred		0.236	0.215	0.198	0.183
104	½" Plaster on ⅜" Plaster Board - Furred		0.246	0.223	0.204	0.188
105	½" Plaster on Wood Lath on 2" Furring Strips - Cellular Gypsum Fill	1⅝"*	0.182	0.169	0.158	0.149
106	½" Plaster on Wood Lath on 2" Furring Strips - Flaked Gypsum Fill	1⅝"*	0.171	0.159	0.150	0.141
107	½" Plaster on Fiber Insulation - (Board form) Furred	½"	0.183	0.170	0.159	0.149
108		1"	0.143	0.135	0.128	0.122
109	½" Plaster on Cork board set in ½" Cement Mortar	1½"	0.133	0.126	0.120	0.114
110		2"	0.109	0.104	0.100	0.096

*Based on 1⅝ in., the actual thickness of 2 in. furring strips.
†The figures on this page may be used with sufficient accuracy for concrete block walls with stucco exterior finish.
‡Resistance of hollow concrete blocks = $\left(\frac{1}{c} = \frac{1}{4.84}\right)$ assumed directly proportional to thickness as with solid homogeneous materials.
Note.—The coefficient used for plasterboard is 3.04 per inch thickness—recent data indicate values as low as 1.30 for this material.
Note.—The coefficient used for cellular gypsum, 0.59 is for 18 lb. weight—weights as low as 12 lb. may be used.

TABLE 8-A. COEFFICIENTS OF TRANSMISSION (*U*) OF VARIOUS TYPES OF FRAME WALL CONSTRUCTION

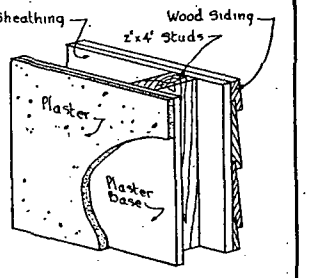
Note.—These coefficients are expressed in B.t.u. per hour per square foot per 1 deg. fahr. difference in temperature between the air on the two sides and are based on an outside wind exposure of 15 miles per hour.

WOOD SIDING OR CLAPBOARD WALLS †

The values of U in this Table are based on the following Internal Conductivities (C) which are expressed in B.t.u. per Hr. per Sq. Ft. per 1°F

Wood (Yellow Pine or Fir)	1.00	per 1"
Plaster (Gypsum)	2.32	per 1"
Wood Lath & Plaster	2.00	as applied
Plaster Board	3.04	per 1"
Cork board	0.30	per 1"
Fiber Insulation (Board form)	0.33	per 1"
Felt or Quilt Insulation (Sq/ft)	0.27	per 1"
Cellular Gypsum (18#)	0.59	per 1"
Flaked Gypsum, Dry (26#)	0.52	per 1"

Typical Construction



Wall Number	Type of Sheathing	Insulation Between Studding	Plaster Base	Coefficient of Transmission U
111	Wood *	None	Wood Lath	0.227
112	Wood *	½" Felt or Quilt ‡ Insulation	Wood Lath	0.129
113	Wood *	½" Fiber Insulation ‡ (Board form)	Wood Lath	0.135
114	Wood *	Cellular Gypsum Fill **	Wood Lath	0.110
115	Wood *	Flaked Gypsum Fill **	Wood Lath	0.101
116	Wood *	None	1½" Cork board	0.110
117	Wood *	None	2" Cork board	0.093
117-A	Wood *	None	½" Fiber Insulation (Board form)	0.178
118	½" Fiber Insulation (Board form)	None	½" Fiber Insulation (Board form)	0.157
119	1" Fiber Insulation (Board form)	None	½" Fiber Insulation (Board form)	0.127
120	½" Fiber Insulation (Board form)	½" Fiber Insulation ‡ (Board form)	½" Fiber Insulation (Board form)	0.107
121	⅜" Plaster Board	None	⅜" Plaster Board	0.280

*Based on ⅝ in., the actual thickness of 1 in. or ¾ in. sheathing.
**Thickness of fill assumed 3⅝ in., based on 2 in. by 4 in. studding.
†Building paper neglected in computations in accordance with accepted practice.
‡Can also be applied on inside of studding with plaster base separated by furring strips.
Note.—The coefficient used for plasterboard is 3.04 per inch thickness—recent data indicate values as low as 1.30 for this material.
Note.—Plasterboard sheathing is now made in half inch thickness.
Note.—The coefficient used for cellular gypsum, 0.59 is for 18 lb. weight—weights as low as 12 lb. may be used.

Table 8-B. Coefficients of Transmission (U) of Various Types of Frame Wall Construction

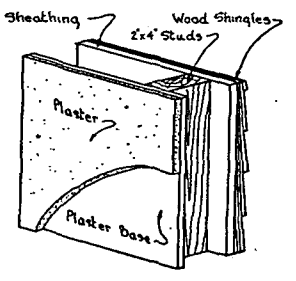
Note.—These coefficients are expressed in B.t.u. per hour per square foot per 1 deg. fahr. difference in temperature between the air on the two sides and are based on an outside wind exposure of 15 miles per hour.

Wood Shingle Walls * *

The values of U in this Table are based on the following Internal Conductivities (C) which are expressed in B.t.u. per Hr. per Sq.Ft. per 1°F

Wood (Yellow Pine or Fir)	1.00	per 1"
Plaster (Gypsum)	2.32	per 1"
Wood Lath & Plaster	2.00	as applied
Plaster Board	3.04	per 1"
Cork board	0.30	per 1"
Fiber Insulation (Board form)	0.33	per 1"
Felt or Quilt Insulation (Sq/ft)	0.27	per 1"
Cellular Gypsum (18")	0.59	per 1"
Flaked Gypsum, Dry (26")	0.52	per 1"

Typical Construction



Wall Number	Type of Sheathing	Insulation Between Studding	Plaster Base	Coefficient of Transmission U
122	Wood *	None	Wood Lath	0.227
123	Wood *	½" Felt or Quilt † Insulation	Wood Lath	0.129
124	Wood *	½" Fiber Insulation † (Board form)	Wood Lath	0.135
125	Wood *	Cellular Gypsum Fill ¶	Wood Lath	0.110
126	Wood *	Flaked Gypsum Fill ¶	Wood Lath	0.101
127	Wood *	None	1½" Cork board	0.110
128	Wood *	None	2" Cork board	0.093
128-A	Wood *	None	½" Fiber Insulation (Board form)	0.178
129	½" Fiber Insulation ‡ (Board form)	None	½" Fiber Insulation (Board form)	0.127
130	1" Fiber Insulation ‡ (Board form)	None	½" Fiber Insulation (Board form)	0.107
131	½" Fiber Insulation ‡ (Board form)	½" Fiber Insulation † (Board form)	½" Fiber Insulation (Board form)	0.092
132	⅜" Plaster Board ‡	None	⅜" Plaster Board	0.197

*Based on 25/32 in., the actual thickness of 1 in. or 3/4 in. sheathing.
**Building paper neglected in computations in accordance with accepted practice.
†Can also be applied on inside of studding with plaster base separated by furring strips.
‡Furring strips between wood shingles and sheathing.
¶Thickness of fill assumed 3⅝ in., based on 2 in. by 4 in. studding.
Note.—The coefficient used for plasterboard is 3.04 per inch thickness—recent data indicate values as low as 1.30 for this material.
Note.—Plasterboard sheathing is now made in half inch thickness.
Note.—The coefficient used for cellular gypsum, 0.59 is for 18 lb. weight—weights as low as 12 lb. may be used.

Table 8-C. Coefficients of Transmission (U) of Various Types of Frame Wall Construction

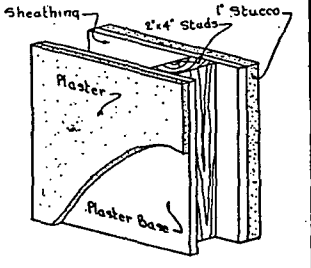
Note.—These coefficients are expressed in B.t.u. per hour per square foot per 1 deg. fahr. difference in temperature between the air on the two sides and are based on an outside wind exposure of 15 miles per hour.

Stucco Walls †

The values of U in this Table are based on the following Internal Conductivities (C) which are expressed in B.t.u. per Hr. per Sq.Ft. per 1°F

Stucco	8.00	per 1"
Wood (Yellow Pine or Fir)	1.00	per 1"
Plaster (Gypsum)	2.32	per 1"
Wood Lath & Plaster	2.00	as applied
Plaster Board	3.04	per 1"
Cork board	0.30	per 1"
Fiber Insulation (Board form)	0.33	per 1"
Felt or Quilt Insulation (Sq/ft)	0.27	per 1"
Cellular Gypsum (18")	0.59	per 1"
Flaked Gypsum, Dry (26")	0.52	per 1"

Typical Construction



Wall Number	Type of Sheathing	Insulation Between Studding	Plaster Base	Coefficient of Transmission U
133	Wood *	None	Wood Lath	0.257
134	Wood *	½" Felt or Quilt ‡ Insulation	Wood Lath	0.138
135	Wood *	½" Fiber Insulation ‡ (Board form)	Wood Lath	0.145
136	Wood *	Cellular Gypsum Fill **	Wood Lath	0.117
137	Wood *	Flaked Gypsum Fill **	Wood Lath	0.107
138	Wood *	None	1½" Cork board	0.116
139	Wood *	None	2" Cork board	0.097
139-A	Wood *	None	½" Fiber Insulation (Board Form)	0.194
140	½" Fiber Insulation (Board form)	None	½" Fiber Insulation (Board form)	0.171
141	1" Fiber Insulation (Board form)	None	½" Fiber Insulation (Board form)	0.136
142	½" Fiber Insulation (Board form)	½" Fiber Insulation (Board form)	½" Fiber Insulation (Board form)	0.113
143	⅜ Plaster Board	None	⅜" Plaster Board	0.326

*Based on 25/32 in., the actual thickness of 1 in. or 3/4 in. sheathing.
**Thickness of fill assumed 3⅝ in., based on 2 in. by 4 in. studding.
†Building paper neglected in computations in accordance with accepted practice.
‡Can also be applied on inside of studding with plaster base separated by furring strips.
Note.—The coefficient used for plasterboard is 3.04 per inch thickness—recent data indicate values as low as 1.30 for this material.
Note.—Plasterboard sheathing is now made in half inch thickness.
Note.—The coefficient used for cellular gypsum, 0.59 is for 18 lb. weight—weights as low as 12 lb. may be used.

TABLE 8-D. COEFFICIENTS OF TRANSMISSION (*U*) OF VARIOUS TYPES OF FRAME WALL CONSTRUCTION

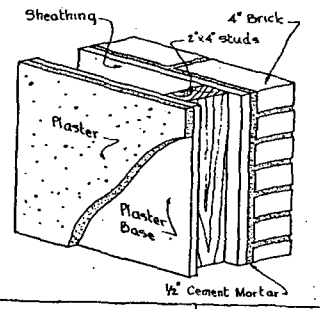
Note.—These coefficients are expressed in B.t.u. per hour per square foot per 1 deg. fahr. difference in temperature between the air on the two sides and are based on an outside wind exposure of 15 miles per hour.

BRICK VENEER WALLS

The values of U in this Table are based on the following Internal Conductivities (C) which are expressed in B.t.u. per Hr. per Sq.Ft. per 1°F

Brick	5.00	per 1"
Cement Mortar	8.00	per 1"
Plaster (Gypsum)	2.32	per 1"
Wood Lath & Plaster	2.00	as applied
Plaster Board	3.04	per 1"
Cork board	0.30	per 1"
Fiber Insulation (Board form)	0.33	per 1"
Felt or Quilt Insulation (Soft)	0.27	per 1"
Cellular Gypsum (18#)	0.59	per 1"
Flaked Gypsum, Dry (26#)	0.52	per 1"

Typical Construction



Wall Number	Type of Sheathing	Insulation Between Studding	Plaster Base	Coefficient of Transmission U
144	Wood *	None	Wood Lath	0.216
145	Wood *	½" Felt or Quilt ‡ Insulation	Wood Lath	0.125
146	Wood *	½" Fiber Insulation ‡ (Board form)	Wood Lath	0.131
147	Wood *	Cellular Gypsum Fill **	Wood Lath	0.108
148	Wood *	Flaked Gypsum Fill **	Wood Lath	0.099
149	Wood *	None	1½" Cork board	0.107
150	Wood *	None	2" Cork board	0.091
150-A	Wood *	None	½" Fiber Insulation (Board form)	0.170
151	½" Fiber Insulation (Board form)	None	½" Fiber Insulation (Board form)	0.152
152	1" Fiber Insulation (Board form)	None	½" Fiber Insulation (Board form)	0.123
153	½" Fiber Insulation (Board form)	½" Fiber Insulation ‡ (Board form)	½" Fiber Insulation (Board form)	0.104
154	⅜" Plaster Board	None	⅜" Plaster Board	0.262

*Based on ⅝ in., the actual thickness of 1 in. or ⅞ in. sheathing.
**Thickness of fill assumed 3⅝ in., based on 2 in. by 4 in. studding.
†Building paper neglected in computations in accordance with accepted practice.
‡Can also be applied to inside of studding with plaster base separated by furring strips.
Note.—The coefficient used for plasterboard is 3.04 per inch thickness—recent data indicate values as low as 1.30 for this material.
Note.—Plasterboard sheathing is now made in half inch thickness.
Note.—The coefficient used for cellular gypsum, 0.59 is for 18 lb. weight—weights as low as 12 lb. may be used.

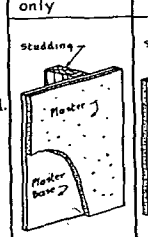
TABLE 9 A AND B. COEFFICIENTS OF TRANSMISSION (*U*) OF VARIOUS TYPES OF INTERIOR WALLS AND PARTITIONS

Note.—These coefficients are expressed in B.t.u. per hour per square foot per 1 deg. fahr. difference in temperature between the air on the two sides and are based on still air (no wind) conditions on both sides.

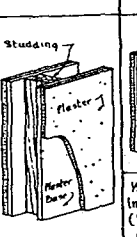
A PLASTERED FRAME PARTITIONS

The values of U in this Table are based on the following Internal Conductivities (C) which are expressed in B.t.u. per Hr. per Sq.Ft. per 1°F

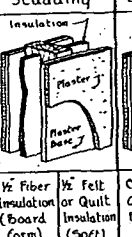
Plaster (Gypsum)	2.32	per 1"
Plaster Board	3.04	per 1"
Wood Lath & Plaster	2.00	as appl'd.
Fiber Ins. (Board form)	0.33	per 1"
Felt or Quilt Ins. (Soft)	0.27	per 1"
Cork board	0.30	per 1"
Cellular Gypsum (18#)	0.59	per 1"
Flaked Gypsum, Dry (26#)	0.52	per 1"



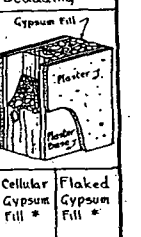
On one side of Studding only



On both sides of Studding



Insulation Between Studding



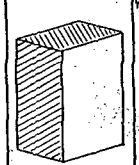
Gypsum Fill Between Studding

Wall No.	Plaster Base	a	b	c ½" Fiber Insulation (Board form)	d ½" Felt or Quilt Insulation (Soft)	e Cellular Gypsum Fill *	f Flaked Gypsum Fill *
155	Metal Lath †	0.551	0.275	0.158	0.143	0.124	0.113
156	Wood Lath ‡	0.502	0.251	0.143	0.136	0.119	0.108
157	⅜" Plaster Board ‡	0.546	0.273				
158	½" Fiber Insulation (Board form) ‡	0.311	0.155	0.106			
159	1" Fiber Insulation (Board form) ‡	0.211	0.106	0.080			
160	1½" Cork board ‡	0.149	0.074				
161	2" Cork board ‡	0.119	0.060				

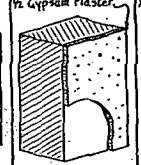
B PLASTERED MASONRY PARTITIONS

The values of U in this Table are based on the following Internal Conductivities (C) which are expressed in B.t.u. per Hr. per Sq.Ft. per 1°F

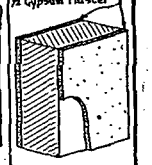
Hollow Clay Tile (4")	0.65	per 4"
Brick	5.00	per 1"
Hollow Gypsum Tile (4")	1.00	per 1"



Plain Walls (No Plaster)



Walls Plastered One Side



Walls Plastered Both Sides

Wall No.	Wall Construction	a	b	c
162	4" Hollow Clay Tile	0.33	0.31	0.29
163	4" Brick	0.44	0.40	0.37
164	4" Hollow Gypsum Tile	0.18	0.175	0.17

*The thickness of the Gypsum Fill is approximately 3⅝ in., as this is the approximate 4 in. dimension of 2 in. by 4 in. studding.
†Metal lath and plaster assumed ¾ in. thick.
‡Plaster assumed ½ in. thick.
Note.—The coefficient used for plasterboard is 3.04 per inch thickness—recent data indicate values as low as 1.30 for this material.
Note.—The coefficient used for cellular gypsum, 0.59 is for 18 lb. weight—weights as low as 12 lb. may be used.

Table 10-A. Coefficients of Transmission (U) of Various Types of Floors and Ceilings

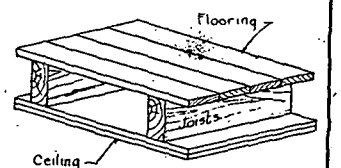
Note.—These coefficients are expressed in B.t.u. per hour per square foot per 1 deg. fahr. difference in temperature between the air on the two sides and are based on still air (no wind) conditions on both sides.

Frame Construction

The values of U in this Table are based on the following Internal Conductivities (C) which are expressed in B.t.u. per Hr. per Sq. Ft. per 1°F

Wood (Yellow Pine or Fir)	1.00	per 1"
Plaster (Gypsum)	2.32	per 1"
Wood Lath & Plaster	2.00	as applied
Plaster Board	3.04	per 1"
Cork board	0.30	per 1"
Fiber Insulation (Board form)	0.33	per 1"
Felt or Quilt Insulation (Sq/t)	0.27	per 1"
Cellular Gypsum (18")	0.59	per 1"
Flaked Gypsum, Dry (26")	0.52	per 1"
Wood (Maple)	1.20	per 1"

Typical Construction



Floor & Ceiling Number	Type of Ceiling	Insulation Between Joists	Type of Flooring: No Flooring	1" Yellow Pine† Flooring on Joists	1" Yellow Pine† Flooring on ½" Fiber Insulation (Board form) on Joists	25/32" Maple or Oak Flooring on 1" Yellow Pine Sub Flooring on Joists
			a	b	c	d
165	No Ceiling	None		0.440	0.264	0.339
166	Metal Lath & Plaster (¾)	None	0.551	0.245	0.179	0.210
167	Wood Lath & Plaster (½")	None	0.502	0.234	0.173	0.202
168	⅜" Plaster Board & Plaster (½")	None	0.546	0.244	0.178	0.209
169	½" Fiber Insulation (Board form) & Plaster (½)	None	0.310	0.181	0.143	0.162
170	Wood Lath & Plaster (1½")	½" Felt or Quilt* Insulation (Sq/t)	0.187	0.131	0.110	0.121
171	Wood Lath & Plaster (½")	½" Fiber Insulation* (Board form)	0.200	0.137	0.114	0.126
172	Wood Lath & Plaster (½)	Cellular Gypsum‡ Fill	0.123	0.112	0.096	0.103
173	Wood Lath & Plaster (1½")	Flaked Gypsum‡ Fill	0.112	0.103	0.089	0.096
174	1½" Cork board & Plaster (½")	None	0.149	0.111	0.095	0.103
175	2" Cork board & Plaster (½")	None	0.119	0.094	0.082	0.088

*The value of U is the same if insulation is applied to underside of joists and lath and plaster ceiling, separated by furring strips.

†Based on actual thickness of approximately 25/32 in. for 1 in. yellow pine flooring.

‡Thickness of fill assumed 3⅝ in., based on 2 in. by 4 in. joists.

Note.—The coefficient used for plasterboard is 3.04 per inch thickness—recent data indicate values as low as 1.30 for this material.

Note.—The coefficient used for cellular gypsum, 0.59 is for 18 lb. weight—weights as low as 12 lb. may be used.

Table 10-B. Coefficients of Transmission (U) of Various Types of Floors and Ceilings

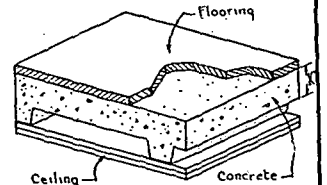
Note.—These coefficients are expressed in B.t.u per hour per square foot per 1 deg. fahr. difference in temperature between the air on the two sides and are based on still air (no wind) conditions on both sides.

Concrete Construction

The values of U in this Table are based on the following Internal Conductivities (C) which are expressed in B.t.u. per Hr. per Sq. Ft. per 1°F

Tile or Terrazzo	10.00	per 1"
Concrete (Stone 1:2:4 mix)	8.30	per 1"
Cement Mortar	8.00	per 1"
Wood (Yellow Pine or Fir)	1.00	per 1"
Plaster Board	3.04	per 1"
Plaster (Gypsum)	2.32	per 1"
Cork board	0.30	per 1"
Fiber Insulation (Board form)	0.33	per 1"
Wood (Maple)	1.20	per 1"

Typical Construction



Floor Number	Type of Ceiling	Thickness of X	Type of Flooring: No Flooring (Concrete bare)*	1" Yellow Pine† Flooring on Wood Sleepers embedded in concrete	25/32" Maple or Oak Flooring on 1" Yellow Pine Sub-Flooring on Wood Sleepers embedded in Concrete	1" Terrazzo or Tile Flooring on Concrete
			a	b	c	d
176	No Ceiling	4"	0.508	0.364	0.292	0.483
177		6"	0.452	0.334	0.273	0.433
178		8"	0.408	0.310	0.256	0.392
179		10"	0.372	0.288	0.241	0.358
180	½" Plaster applied directly to underside of Concrete	4"	0.457	0.337	0.275	0.437
181		6"	0.411	0.311	0.258	0.395
182		8"	0.374	0.290	0.243	0.361
183		10"	0.344	0.271	0.230	0.332
184	Suspended or furred Metal Lath & Plaster Ceiling	4"	0.264	0.219	0.191	0.258
185		6"	0.248	0.208	0.183	0.242
186		8"	0.234	0.198	0.175	0.229
187		10"	0.222	0.189	0.168	0.217
188	Suspended or furred Ceiling of ⅜" Plaster-Board & Plaster	4"	0.263	0.218	0.190	0.256
189		6"	0.247	0.207	0.182	0.241
190		8"	0.234	0.198	0.174	0.228
191		10"	0.221	0.189	0.167	0.216
192	Suspended or furred Ceiling of ½" Fiber Insulation (Board form) & ½" Plaster	4"	0.193	0.167	0.151	0.189
193		6"	0.184	0.161	0.145	0.181
194		8"	0.176	0.155	0.140	0.173
195		10"	0.169	0.149	0.136	0.166
196	½" Plaster on 1½" Cork board set in ½" Cement Mortar on Concrete	4"	0.138	0.124	0.115	0.136
197		6"	0.133	0.121	0.112	0.132
198		8"	0.129	0.117	0.109	0.128
199		10"	0.125	0.114	0.106	0.124
200	½" Plaster on 2" Cork board set in ½" Cement Mortar on Concrete	4"	0.112	0.103	0.097	0.111
201		6"	0.109	0.101	0.094	0.108
202		8"	0.106	0.098	0.092	0.105
203		10"	0.104	0.096	0.090	0.103

*The figures in column "a" are sufficiently accurate for concrete floors covered with carpet or linoleum.

†The figures in column "b" are sufficiently accurate for ⅝ in. maple or oak flooring applied directly over the concrete on wood sleepers.

Note.—The coefficient used for plasterboard is 3.04 per inch thickness—recent data indicate values as low as 1.30 for this material.

TABLE 10-C. COEFFICIENTS OF TRANSMISSION (*U*) OF VARIOUS TYPES OF FLOORS AND CEILINGS

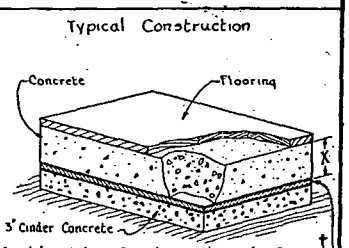
Note.—These coefficients are expressed in B.t.u. per hour per square foot per 1 deg. fahr. difference in temperature between the ground and the air over the floor and are based on still air (no wind) conditions.

CONCRETE CONSTRUCTION ON GROUND *

The values of U in this Table are based on the following Internal Conductivities (C) which are expressed in B.t.u. per Hr. per Sq. Ft. per 1°F

Tile or Terrazzo	10.00	per 1"
Concrete (Stone 1:2:4 mix)	8.30	per 1"
Cinder Concrete	5.20	per 1"
Wood (Yellow Pine)	1.00	per 1"
Wood (Maple)	1.20	per 1"
Fiber Insulation (Board form)	0.33	per 1"
Cork board	0.30	per 1"

Typical Construction



Y = Thickness of Insulation in Inches where specified

Insulation between 2 membrane waterproofing Courses †

Floor Number	Type of Insulation (between cinder & Stone Concrete)	Thickness Y	Thickness X	Type of Flooring: No Flooring (Concrete bare)	1" Yellow Pine Flooring on Wood Sleepers embedded in Concrete ‡	13/16 Maple or Oak Flooring on 1" Yellow Pine Sub-Flooring on Wood Sleepers embedded in Concrete	1" Terrazzo or Tile Flooring on Concrete
				a	b	c	d
204	No Insulation	0"	4"	0.556	0.388	0.308	0.526
205		0"	5"	0.521	0.370	0.297	0.495
206		0"	6"	0.490	0.355	0.286	0.467
207		0"	8"	0.439	0.327	0.268	0.420
208	Fiber Insulation (Board form)	1"	4"	0.207	0.178	0.159	0.203
209		1"	5"	0.202	0.174	0.156	0.198
210		1"	6"	0.197	0.171	0.153	0.193
211		1"	8"	0.188	0.164	0.148	0.185
212	Cork board	2"	4"	0.118	0.108	0.101	0.117
213		2"	5"	0.116	0.107	0.100	0.115
214		2"	6"	0.115	0.105	0.098	0.113
215		2"	8"	0.112	0.103	0.096	0.110

*Assume ground temperature to be 50 deg. fahr.

†Membrane water proofing neglected in calculations.

‡The figures in column "b" may be used with sufficient accuracy for maple or oak flooring on wood sleepers embedded in concrete.

TABLE 11-A. COEFFICIENTS OF TRANSMISSION (*U*) OF VARIOUS TYPES OF FLAT ROOFS COVERED WITH BUILT-UP ROOFING

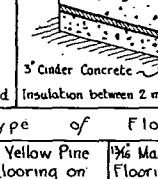
Note.—These coefficients are expressed in B.t.u per hour per square foot per 1 deg. fahr. difference in temperature between the air on the two sides and are based on an outside wind exposure of 15 miles per hour.

FLAT ROOFS - NO PLASTER CEILINGS (UNDERSIDE OF ROOF DECK UNFINISHED)

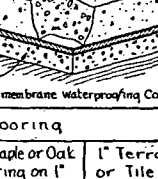
The values of U in this Table are based on the following Internal Conductivities (C) which are expressed in B.t.u. per Sq.Ft. per 1°F

Roofing	1.325 per 1"
Concrete	8.30 per 1"
Gypsum (15% wood fiber)	2.30 per 1"
Wood (Yellow Pine or Fir)	1.00 per 1"
Fiber Insulation (Board form)	0.33 per 1"
Felts & Quilts (Soft)	0.27 per 1"
Cork board	0.30 per 1"
Plaster Board	3.04 per 1"
Cellular Gypsum (24#)	0.77 per 1"

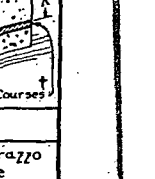
Concrete Roofs



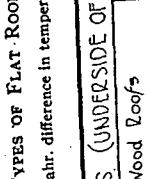
Wood Roofs



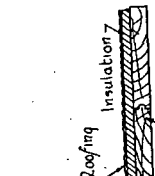
Poured Gypsum Containing 15% Wood Fiber



Flat Metal Roofs



Corrugated Iron Roofs



Roof No.	Thickness of Insulation	Kind of Insulation	Concrete Roofs: Thickness - X 1⅝* a	2" b	3" c	4" d	5" e	6" f	Wood Roofs: Thickness - X 1" g	1½" h	2" i	3" j	4" k	Poured Gypsum Containing 15% Wood Fiber: Thickness - X 3" l	4" m	Flat Metal Roofs n	Corrugated Iron Roofs o
216	0"	No Insulation	0.680	0.658	0.610	0.568	0.532	0.500	0.485	0.386	0.345	0.256	0.204	0.369	0.318	0.781	1.50 ‡
217	½"	Fiber Insulation (Board form)	0.334	0.330	0.317	0.306	0.295	0.285	0.280	0.243	0.226	0.184	0.156	0.237	0.214	0.358	
218	1"		0.222	0.220	0.214	0.209	0.203	0.199	0.196	0.178	0.168	0.144	0.126	0.174	0.162	0.232	
219	1½"		0.166	0.165	0.162	0.159	0.156	0.153	0.151	0.140	0.134	0.118	0.106	0.138	0.130	0.172	
220	2"		0.133	0.132	0.130	0.128	0.126	0.124	0.123	0.116	0.112	0.100	0.091	0.114	0.109	0.136	
221	1"	Cork board	0.208	0.206	0.201	0.196	0.192	0.188	0.185	0.169	0.160	0.138	0.121	0.165	0.154	0.217	
222	1½"		0.154	0.153	0.151	0.148	0.145	0.143	0.142	0.132	0.126	0.124	0.101	0.130	0.120	0.160	
223	2"		0.123	0.122	0.120	0.119	0.117	0.115	0.114	0.108	0.104	0.095	0.086	0.107	0.102	0.126	
224	½"	Soft Felt or Quilt (Not Compressed)	0.301	0.297	0.286	0.277	0.268	0.260	0.256	0.225	0.210	0.174	0.148	0 219	0.200	0.319	
225	1"		0.193	0.191	0.187	0.183	0.179	0.175	0.174	0.159	0.151	0.131	0.116	0.156	0.146	0.211	
226	2"	Cellular Gypsum	0.246	0.243	0.236	0.229	0.223	0.217	0.214	0.193	0.182	0.154	0.133				

*Pre cast cement.
†Nominal thicknesses specified—actual thicknesses used in computations.
‡No built-up roofing. The value for corrugated iron is obtained by assuming that the surface area is increased 50 per cent.

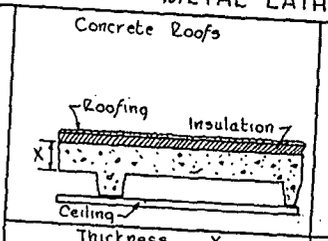
TABLE 11-B. COEFFICIENTS OF TRANSMISSION (*U*) OF VARIOUS TYPES OF FLAT ROOFS COVERED WITH BUILT-UP ROOFING

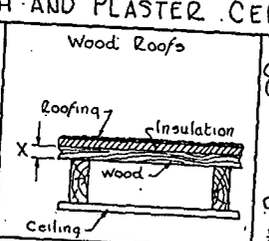
Note.—These coefficients are expressed in B.t.u. per hour per square foot per 1 deg. fahr. difference in temperature between the air on the two sides and are based on an outside wind exposure of 15 miles per hour.

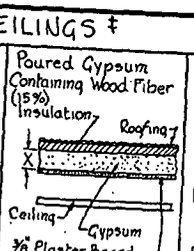
FLAT ROOFS — METAL LATH AND PLASTER CEILINGS ‡

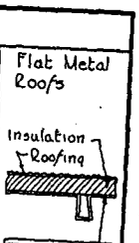
The values of U in this Table are based on the following Internal Conductivities (C) which are expressed in B.t.u. per Hr. per Sq.Ft. per 1°F

Roofing	1.325	per 1"
Concrete	8.30	per 1"
Gypsum (15% Wood fiber)	2.50	per 1"
Wood (Yellow Pine or Fir)	1.00	per 1"
Fiber Insulation (Board form)	0.33	per 1"
Felts & Quilts (Soft)	0.27	per 1"
Cork board	0.30	per 1"
Plaster (Gypsum)	2.32	per 1"
Cellular Gypsum (24#)	0.77	per 1"









Roof No.	Thickness of Insulation	Kind of Insulation	Concrete Roofs — Thickness - X						Wood Roofs — Thickness - X †					Poured Gypsum Containing Wood Fiber (15%) — Thickness - X		Flat Metal Roofs
			1⅜"	2"	3"	4"	5"	6"	1"	1½"	2"	3"	4"	3"	4"	
			a	b	c	d	e	f	g	h	i	j	k	l	m	n
227	0"	No Insulation	0.304	0.300	0.290	0.280	0.271	0.262	0.258	0.227	0.213	0.175	0.149	0.221	0.202	0.324
228	½"	Fiber Insulation (Board form)	0.208	0.206	0.201	0.196	0.192	0.188	0.185	0.169	0.160	0.138	0.121	0.165	0.154	0.217
229	1"		0.158	0.157	0.154	0.152	0.149	0.146	0.145	0.133	0.129	0.114	0.102	0.132	0.125	0.163
230	1½"		0.128	0.127	0.125	0.123	0.121	0.119	0.119	0.112	0.108	0.097	0.089	0.110	0.105	0.131
231	2"		0.107	0.106	0.105	0.104	0.102	0.101	0.101	0.096	0.093	0.085	0.078	0.095	0.091	0.109
232	1"	Cork board	0.151	0.150	0.147	0.145	0.142	0.140	0.138	0.129	0.124	0.110	0.100	0.127	0.120	0.155
233	1½"		0.121	0.120	0.118	0.116	0.115	0.113	0.112	0.106	0.103	0.093	0.085	0.105	0.104	0.123
234	2"		0.100	0.100	0.099	0.098	0.096	0.095	0.095	0.090	0.088	0.081	0.075	0.089	0.086	0.102
235	½"	Soft Felt or Quilt (Not Compressed)	0.194	0.192	0.188	0.184	0.180	0.176	0.174	0.160	0.152	0.132	0.116	0.157	0.147	0.202
236	1"		0.143	0.142	0.139	0.137	0.135	0.133	0.132	0.123	0.118	0.106	0.096	0.121	0.115	0.147
237	2"	Cellular Gypsum	0.170	0.168	0.165	0.162	0.159	0.156	0.154	0.143	0.136	0.120	0.107			

*Pre cast cement.
†Nominal thickness specified—actual thicknesses used in computations.
‡The figures in this table may be used with sufficient accuracy for wood lath and plaster ceilings.

TABLE 12-A. COEFFICIENTS OF TRANSMISSION (*U*) OF VARIOUS TYPES OF PITCHED ROOFS

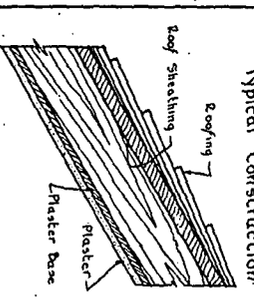
Note.—These coefficients are expressed in B.t.u. per hour per square foot per 1 deg. fahr. difference in temperature between the air on the two sides and are based on an outside wind exposure of 15 miles per hour.

HEATED ATTICS

The values of U in this Table are based on the following Internal Conductivities (C) which are expressed in B.t.u. per Hr. per Sq. Ft. per 1°F

Asphalt or Composition Roofing	6.50 as applied
Asbestos Shingles	6.00 as applied
Slate Shingles	10.37 per 1"
Wood (Yellow Pine or Fir)	1.00 per 1"
Wood Lath & Plaster	2.00 as applied
Plaster Board	3.04 per 1"
Plaster (Gypsum)	2.32 per 1"
Fiber Insulation (Board form)	0.33 per 1"
Felt or Quilt Insulation (Soft)	0.27 per 1"
Cork board	0.30 per 1"
Cellular Gypsum (18#)	0.59 per 1"
Flaked Gypsum, Dry (12#)	0.52 per 1"

Typical Construction



Roof Number	Type of Ceiling	Insulation between Roof Rafters	Type of Roofing & Roof Sheathing: Wood Shingles on Wood Strips*	Asphalt Shingles or Composition Roofing on Wood Sheathing	Rigid Asbestos Shingles on Wood Sheathing	Slate or Tile and Roofing Felt on Wood Sheathing
			a	b	c	d
238	No Ceiling (Rafters exposed)	None	0.483	0.518	0.515	0.549
239	Wood Lath & Plaster (½")	None	0.246	0.259	0.259	0.262
240	Wood Lath & Plaster (½")	½" Felt or Quilt Insulation (Soft)	0.136	0.139	0.139	0.141
241	Wood Lath & Plaster (½")	1" Felt or Quilt Insulation (Soft) †	0.109	0.111	0.111	0.112
242	Wood Lath & Plaster (½")	½" Fiber Insulation (Board form)	0.141	0.144	0.144	0.146
243	Wood Lath & Plaster (½")	1" Fiber Insulation† (Board form)	0.116	0.118	0.118	0.119
244	Wood Lath & Plaster (½")	Cellular Gypsum Fill ‡	0.108	0.116	0.116	0.118
245	Wood Lath & Plaster (½")	Flaked Gypsum Fill ‡	0.099	0.109	0.109	0.110
246	⅜ Plaster Board & Plaster (½")	None	0.256	0.266	0.265	0.274
247	1½" Cork board & Plaster (½")	None	0.114	0.115	0.115	0.117
248	2" Cork board & Plaster (½")	None	0.096	0.097	0.097	0.098
249	½" Fiber Insulation (Board form) & Plaster (½")	½" Fiber Insulation† (Board form)	0.120	0.122	0.122	0.124
250	½" Fiber Insulation (Board form) & Plaster (½")	None	0.189	0.194	0.193	0.198

*Based on 1 in. by 4 in., spaced 2 in. Can also be applied to underside of roof rafters with furring strips between.
†Assumed 3¾ in. thick, based on 2 in. by 4 in. rafters.
‡*Note.*—The coefficient used for plasterboard is 3.04 per inch thickness—recent data indicate values as low as 1.30 for this material.
Note.—The coefficient used for cellular gypsum, 0.59 is for 18 lb. weight—weights as low as 12 lb. may be used.

Table 12-B. Coefficients of Transmission of Various Types of Pitched Roofs

Note.—The figures on this page are the combined coefficients of transmission of pitched roofs, under a difference in temperature between the air underneath the ceiling and the outside air. An average of attics, and top floor ceilings, and are expressed in B.t.u. per hour per square foot of roof area per 1 deg. fahr. accurate for roofs ranging from ¼ pitch to ½ pitch. Exposure of 15 miles has been assumed. These coefficients are based on ½ pitched roofs, but are sufficiently

Unheated Attics

The values of U in this Table are based on the following Internal Conductivities (C) which are expressed in B.t.u. per Hr. per Sq. Ft. per 1°F

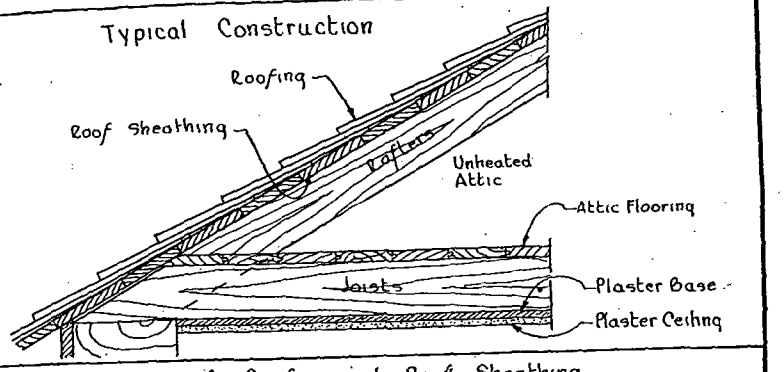
Asphalt or Composition Roofing	6.50	as applied
Asbestos Shingles	6.00	as applied
Slate Shingles	10.37	per 1"
Wood (Yellow Pine or Fir)	1.00	per 1"
Wood Lath & Plaster	2.00	as applied
Plaster Board	3.04	per 1"
Plaster (Gypsum)	2.32	per 1"
Fiber Insulation (Board form)	0.33	per 1"
Felt or Quilt Insulation (Soft)	0.27	per 1"
Cork board	0.30	per 1"
Cellular Gypsum (18*)	0.59	per 1"
Flaked Gypsum, Dry (26*)	0.52	per 1"

Roof Number	Type of Ceiling	Insulation on underside of Roof Rafters	Insulation between Ceiling Joists
251	Wood Lath & Plaster (½")	None	None
252	Wood Lath & Plaster (½")	None	1" Felt or Quilt † Insulation (Soft)
253	Wood Lath & Plaster (½")	½" Fiber Insulation (Board form)	½" Fiber Insulation † (Board form)
254	Wood Lath & Plaster (½")	None	3⅝" Cellular Gypsum Fill
255	Wood Lath & Plaster (½")	None	3⅝" Flaked Gypsum Fill
256	⅜" Plaster Board & Plaster (½")	None	None
257	1½" Cork board & Plaster (½")	None	None
258	2" Cork board & Plaster (½")	None	None
259	½" Fiber Insulation (Board form) & Plaster (½")	None	None
260	½" Fiber Insulation (Board form) & Plaster (½")	½" Fiber Insulation (Board form)	½" Fiber Insulation (Board form)

*Based on 1 in. by 4 in., spaced 2 in.
†Can also be applied to underside of ceiling joists with furring strips between insulation and ceiling.
‡Based on actual thickness of 1 in. lumber of approximately ¾ in.
Note.—The coefficient used for plasterboard is 3.04 per inch thickness—recent data indicate values as low as 1.30 for this material.
Note.—The coefficient used for cellular gypsum, 0.59 is for 18 lb. weight—weights as low as 12 lb. may be used.

Attics

Typical Construction



Roof Number	Type of Roofing and Roof Sheathing							
	Wood Shingles on Wood Strips *		Asphalt Shingles or Composition Roofing on Wood Sheathing		Rigid Asbestos Shingles on Wood Sheathing		Slate or Tile and Roofing Felt on Wood Sheathing	
	No Attic Flooring	1"x6" Y. P. ‡ Attic Flooring	No Attic Flooring	1"x6" Y. P. ‡ Attic Flooring	No Attic Flooring	1"x6" Y. P. ‡ Attic Flooring	No Attic Flooring	1"x6" Y. P. ‡ Attic Flooring
	a	b	c	d	e	f	g	h
251	0.224	0.139	0.231	0.141	0.230	0.141	0.237	0.143
252	0.118	0.089	0.120	0.090	0.120	0.090	0.121	0.091
253	0.090	0.074	0.091	0.073	0.091	0.073	0.089	0.074
254	0.085	0.078	0.086	0.079	0.086	0.079	0.086	0.080
255	0.078	0.073	0.079	0.074	0.079	0.074	0.080	0.074
256	0.235	0.143	0.243	0.146	0.242	0.146	0.249	0.148
257	0.099	0.078	0.100	0.079	0.100	0.079	0.101	0.079
258	0.082	0.067	0.083	0.068	0.083	0.068	0.084	0.068
259	0.168	0.115	0.172	0.117	0.172	0.117	0.176	0.118
260	0.080	0.066	0.080	0.066	0.080	0.066	0.081	0.067

*Based on 1 in. by 4 in., spaced 2 in.
†Can also be applied to underside of ceiling joists with furring strips between insulation and ceiling.
‡Based on actual thickness of 1 in. lumber of approximately ¾ in.
Note.—The coefficient used for plasterboard is 3.04 per inch thickness—recent data indicate values as low as 1.30 for this material.
Note.—The coefficient used for cellular gypsum, 0.59 is for 18 lb. weight—weights as low as 12 lb. may be used.

If a roof contains two or more dormers and the attic is unheated, it is advisable to disregard the roof structure proper and consider only the top-floor ceiling in determining the radiation requirements of the building. In this case it will be necessary to assume the temperature in the attic, which can be taken to be the mean between the temperature under the top-floor ceiling (not the attic) and the outside temperature.

AREAS WHERE HEAT LOSSES OCCUR

Heat is lost from a building by transmission through all of those surfaces which separate heated spaces from the outside air or from unheated colder spaces within the building. In general, five kinds of surfaces are involved: (1) outside walls, (2) outside glass, (3) inside walls or partitions next to unheated spaces, (4) ceilings of upper floors, either below a cold attic space or as the underside of a roof slab, and (5) floors of heated rooms above an unheated space. In most cases, only items (1) and (2), outside wall and glass surface, are considered. Failure to take account of the other heat losing surfaces, items (3), (4) and (5), when they exist in a building, has generally resulted in more or less dissatisfaction with the operation of the heating plant, as a result of failure to heat the rooms having such surfaces as indicated by items (3), (4) and (5).

The net outside wall surface is usually determined by reference to the scale plans and elevations of the building concerned. In some cases of course, the actual building may have to be measured. The total area of all outside openings which are occupied by windows and doors is accurately measured and listed as *glass*. The *glass* area is then deducted from the total outside wall area for each room and the difference is the net wall area. The outside wall areas for any floor should be based on the vertical floor to floor heights and the horizontal distance from center to center of partitions separating different rooms. If there are no partitions, measure from inside face of one wall to inside face of next wall. The areas of walls, ceilings and floors next to cold or unheated spaces are found, of course, by taking the inside dimensions of such areas, measured on the heated side.

CALCULATIONS FOR HEAT TRANSMISSION LOSSES

The calculations for heat transmission losses are made by multiplying the area S in square feet of wall, glass, roof or floor through which the loss takes place, by the proper coefficient U for such construction (Tables 7 to 13, or by computation as described under Transmission Coefficients by Computation) and by the temperature difference between the inside air temperature t at the proper level (in many cases not the "breathing line") and the outside air temperature t_o. Therefore,

$$H_t = SU\,(t - t_o) \qquad (9)$$

where

H_t = B.t.u. per hr. transmitted through the material of the wall, glass, roof or floor.
S = area in sq. ft. of wall, glass, roof or floor, taken from building plans or actually measured. (Use the net inside or heated surface dimensions in all cases.)

U = coefficient of heat transmission or B.t.u. per hr. per sq. ft. per 1 deg. fahr. difference between the inside and outside air temperature for air conditions such as exist in the given locality in coldest weather.
$(t - t_o)$ = temperature difference between inside and outside air, in which t must always be taken at the proper level. Note that t may not be the "breathing-line" temperature in many cases.

For examples showing application of equation (9) to practical examples see *Applications* at the end of this chapter, in which the heat requirements are computed for typical cases.

Wind Movement

The effect of wind on the heating requirements of any building should be given consideration under two heads:

1. Wind movement increases the heat transmission of walls, glass, and roof, affecting poor walls to a much greater extent than good walls.
2. Wind movement materially increases the infiltration (inleakage) of cold air through the cracks around doors and windows, and even through the building materials themselves, if such materials are at all porous.

It is entirely possible that a building may require more heat on a windy day with a moderately low outside temperature, than on a quiet day with a much lower outside temperature. It will therefore be evident that the wind movement in any locality must be given careful consideration in computing the probable heating requirements of a building, and for the purposes of calculation, not less than the average wind movement in any locality during December, January and February should always be provided for in computing (1) the heat transmission of a building, and (2) the heat required to take care of the infiltration of outside air.

The first condition is readily taken care of as already explained, by using a surface coefficient K, for the outside wall surface which is based on the proper wind velocity (Table 6). In case specific data are lacking

TABLE 13. COEFFICIENTS OF TRANSMISSION (U) OF DOORS, WINDOWS AND SKYLIGHTS

NOTE.—These coefficients are based on a wind exposure of 15 miles per hour, and are expressed in B.t.u. per hour per square foot per deg. fahr. difference in temperature between the air inside and outside of the door, window or skylight.

A. Windows and Skylights

	U
Single	1.13*†
Double	0.45*
Triple	0.281*

*B. Solid Wood Doors***†

Nominal Thickness Inches	Actual Thickness Inches	U
1	$\frac{25}{32}$	0.563
1¼	$1\frac{1}{16}$	0.485
1½	$1\frac{5}{16}$	0.432
2	$1\frac{5}{8}$	0.382
2½	$2\frac{1}{8}$	0.321
3	$2\frac{5}{8}$	0.277

*See page 59, Volume I, "Mechanical Equipment of Buildings," by Harding and Willard.
**Computed using $C = 1.0$ for wood, $K_1 = 1.34$ and $K_2 = 4.02$.
†It is sufficiently accurate to use the same coefficient of transmission for doors containing thin wood panels, as that of single panes of glass, namely, 1.13 B.t.u. per hr. per square foot per 1 deg. fahr. difference between inside and outside air temperature.

for any locality, use an average wind velocity of approximately 15 miles per hour. In a similar manner, the heat allowance (Tables 14 to 19 for infiltration (B.t.u. per hour per foot of crack required to raise the temperature of the air leaking in through one degree) through cracks, must be based on the average wind velocity for a given locality, and is explained in the next subdivision of this chapter.

Wind movement involves both *direction* and *velocity*, and hence after transmission and infiltration losses have been computed, using coefficients which allow for average velocity, a further allowance must be made for the direction of the prevailing wind in any given locality. This shall be done by adding 15 per cent to the wall and glass transmission losses and

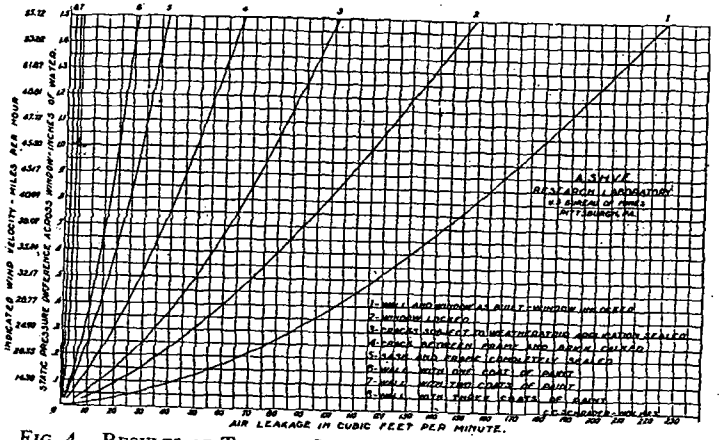


FIG. 4. RESULTS OF TESTS OF LEAKAGE THROUGH VARIOUS PARTS OF WINDOW AND FRAME

Note.—The above figure gives the total leakage of various parts of the window. The window measured 2 ft. 8 in. by 5 ft. 2 in. with a perimeter of 18.25 ft. To obtain the average leakage per hour per foot of crack, multiply the readings from the curves by 60 and divide by 18.25.

the infiltration losses on the sides of the building exposed to the prevailing winds. Those walls which lie in the two adjacent sides of the building most nearly facing the prevailing wind are to be considered in making this correction. This is not necessarily the same as adding 15 per cent to the total heat loss of a room on the exposed sides of the building.

INFILTRATION RESULTING FROM WIND MOVEMENT[6]

Reference has already been made to the fact that in addition to the heat transmission of the walls, glass and roof, consideration must always be given to the inleakage of cold outside air which must be heated to room temperature. This inleakage or infiltration is exclusive and independent of air that may be supplied for ventilation through ducts or flues of any sort. Calculation of the heat required for this purpose is a

[6]Material on infiltration prepared especially for THE GUIDE by a committee consisting of Prof. G. L. Larson, *chairman*; D. K. Boyd; Prof. J. E. Emswiler, Prof. A. P. Kratz and L. B. Lent.

very simple matter if the volume of air leaking into the building per hour is known.

$$H_i = 0.24\ Q\ d\ (t - t_o) \qquad (10)$$

where

H_i = B. t.u. per hour required for heating air leaking into building from outside temperature t_o to breathing-line temperature t.
Q = cubic feet of air entering per hour at breathing-line temperature, t.
d = density (lb. per cu. ft.) of air at breathing-line temperature, t.
t = breathing-line temperature.
t_o = outside air temperature for which heating system is designed.
0.24 = specific heat of air.

The determination of Q, the amount of air leaking in per hour, may be arrived at in either of two ways: (1) by assuming a certain number of air changes per hour for each room, the number of changes assumed (Table 14) being dependent upon the type, use, and location of room, or (2) by computing the infiltration taking place through the cracks around windows and doors in that side of the room which has the greatest number of feet of such crack. In no case should the amount of crack used for computation be less than half of the total crack in the outside walls of the room. Thus, in a room with one exposed wall, take all the crack; with two exposed walls take the wall having the most crack; and with three or four exposed walls take the wall having the most crack, but in no case take less than half the total crack.

The linear feet of crack for a double hung sash is equal to the sash perimeter plus the meeting rail. For a standard type steel sash constructed of solid rolled sections (Fenestra, Lupton and others) the linear feet of crack consists of the perimeter of the ventilating section plus the linear feet of sash section in contact with steel work as, for example, vertical and horizontal mullion steel. The perimeter of sash properly grouted with cement mortar into brickwork or concrete is not to be counted as crack.

Neither of these methods for estimating the infiltration is entirely satisfactory in view of the limited amount of data available, but for the purposes of calculation the second (infiltration) method is to be preferred and then checked against the first (air changes per hour) method. In no case use less than one-half an air change where outside doors and windows exist. The infiltration method based on tests of windows by F. C.

TABLE 14. AIR CHANGES TAKING PLACE UNDER AVERAGE CONDITIONS EXCLUSIVE OF AIR PROVIDED FOR VENTILATION

Kind of Room or Building	Number of Air Changes Taking Place per Hour
Rooms, 1 side exposed	1
Rooms, 2 sides exposed	1½
Rooms, 3 sides exposed	2
Rooms, 4 sides exposed	2
Rooms with no windows or outside doors	½ to ¾
Entrance Halls	2 to 3
Reception Halls	2
Living Rooms	1 to 2
Dining Rooms	1 to 2
Bath Rooms	2
Drug Stores	2 to 3
Clothing Stores	1
Churches, Factories, Lofts, etc.	½ to 3

Houghten and C. C. Schrader, reported in TRANSACTIONS, A.S.H. & V.E., Vol. 30, 1924 and Vol. 31, 1925 and others, including the tests by F. C. Houghten and M. E. O'Connell reported in the JOURNAL, A. S. H. & V. E., Vol. 33, No. 11, papers by J. E. Emswiler and W. C. Randall recorded in the JOURNAL of the A. S. H. & V. E., Vol. 34, No. 6, and by F. C. Houghten and M. E. O'Connell recorded in the JOURNAL of the A. S. H. & V. E., Vol. 34, No. 7, may be conveniently adapted to calculation purposes. Similarly, for walls the tests by F. C. Houghten and M. Ingels reported in the JOURNAL, A. S. H. & V. E., Vol. 33, No. 4 may be used.

Table 15 as well as Figs. 4 and 6 present values from the tests by Houghten and Schrader at the Research Laboratory of the American Society of Heating and Ventilating Engineers at Pittsburgh. Table 16 is taken from the more recent tests made by Houghten and O'Connell on windows installed in the Southwestern Bell Telephone Company Building in St. Louis. The original report for the data of Table 15 and Fig. 4 is to be found in TRANSACTIONS, A. S. H. & V. E., Vol. 30, 1924, No. 686, p. 105, and for Fig. 6 the data were presented in the TRANSACTIONS, A. S. H. & V. E., Vol. 30, 1924, No. 704, p. 313. Table 16 is based on data reported in the JOURNAL, Vol. 33, No. 11. Table 17 is based on data obtained on walls at the Research Laboratory of the Society as reported in the JOURNAL, Vol. 33, No. 4. Figs. 7 and 8 are taken from the paper by W. M. Richtman and C. Braatz, "Effect of Frame Calking and Storm Windows on Infiltration Around and Through Windows," as reported in the JOURNAL, Vol. 34, No. 9.

Table 15 gives the leakage for a double-hung wood window not weatherstripped and the leakage for the same window fitted with a good weatherstrip for various wind velocities. Table 16 gives the leakage for double-hung metal windows weatherstripped and non-weatherstripped.

Table 17 gives the leakage through brick and wood frame walls, with and without plaster. In addition to the information in this table, the authors make the following statement: "In the case of walls with furring, lath, and plaster painted, walls plastered directly on the brick with or without paint or frame walls with plaster painted, the leakage is so small as to require about 0.10 of a square foot of radiation per 100 sq. ft. of wall, or in fact, it could be said that the heat loss due to infiltration of such walls is negligible."

Table 18 gives values for infiltration through steel windows of the rolled section type with pivoted or swinging ventilators, and is derived from data presented by Emswiler and Randall in the JOURNAL, Vol. 34, No. 6. The crack widths appearing in the Table are chosen as representative of a large number of measurements of installed steel windows of the type tested.

Table 19 presents some figures for infiltration through a steel window of the hollow metal vertically pivoted type tested in place in a building, by Houghten and O'Connell, and reported in the JOURNAL, Vol. 34, No. 7. The crack width was not given, but it was stated that the sash was not in good shape and fitted loosely in the frame.

Tables 15, 16, 17 and 18 are divided into two parts, the first part containing values based upon the original test data, and the second part

TABLE 15. INFILTRATION THROUGH DOUBLE HUNG WOOD SASH WINDOWS

	Wind Velocity Miles per Hour	Per Foot of Uncaulked Crack Around Frame*			Per Foot of Crack around the Sash including meeting rail for Cracks of ⅛ in. and ¼ in. Clearance, Window Unlocked					
					Plain Non-Stripped Wood Window			Average Weatherstripped Window		
		Leakage Cu. Ft. per Hour.	Heat Loss B.t.u. per Hour 0-70 Deg. Fahr.	Sq. Ft. Radiation	Leakage Cu. Ft. per Hour	Heat Loss B.t.u. per Hour 0-70 Deg. Fahr.	Sq. Ft. Radiation	Leakage Cu. Ft. per Hour	Heat Loss B.t.u. per Hour 0-70 Deg. Fahr.	Sq. Ft. Radiation
PART I Values actually determined by Laboratory tests.	5.0	1.76	2.22	0.009	49.1	62.0	0.26	3.75	4.76	0.020
	7.5	7.95	10.1	0.042	78.6	99.1	0.42	8.52	10.8	0.045
	10.0	14.1	17.9	0.075	106.0	134.0	0.56	14.7	18.7	0.078
	15.0	28.3	35.9	0.15	155.0	196.0	0.82	28.6	36.4	0.15
	20.0	38.8	49.3	0.21	201.0	254.0	1.06	43.6	55.4	0.23
	30.0	67.1	85.3	0.36	291.0	367.0	1.54	74.5	93.9	0.39
	40.0	95.0	121.0	0.51	386.0	487.0	2.03	110.0	138.0	0.58
	50.0	111.0	141.0	0.59	488.0	615.0	2.56	146.0	185.0	0.78
PART II Values for practical use; average test values reduced by 20 per cent to allow for building up of pressure in room, etc.	5.0	1.41	1.77	0.007	39.3	49.5	0.21	3.00	3.80	0.016
	7.5	6.36	8.08	0.034	62.8	79.2	0.33	6.82	8.60	0.036
	10.0	11.3	14.3	0.060	84.9	107.0	0.45	11.7	14.9	0.062
	15.0	22.6	28.7	0.12	124.0	157.0	0.65	22.9	29.1	0.12
	20.0	31.1	39.4	0.16	161.0	203.0	0.85	34.9	44.3	0.19
	30.0	53.6	68.2	0.28	233.0	294.0	1.23	59.6	75.6	0.32
	40.0	76.0	96.5	0.40	309.0	390.0	1.63	87.8	111.0	0.46
	50.0	88.9	114.0	0.48	390.0	492.0	2.05	117.0	148.0	0.62

Notes.—A. The above table is approximately correct for cracks up to ¼ in.

B. The values given for the plain non-stripped wood window and for the weatherstripped window include the "elsewhere" leakage through the frame, but not the leakage through the uncaulked crack around the frame. If the frame is to be left uncaulked the loss under that heading should be included in the heat loss calculations.

*Practically all leakage around frames can be stopped by proper calking.

TABLE 16. INFILTRATION THROUGH DOUBLE HUNG METAL SASH WINDOWS PER FOOT OF CRACK

	Wind Velocity Miles per Hour	Non-Weatherstripped Window, Locked			Non-Weatherstripped Window, Unlocked			Weatherstripped Window, Unlocked		
		Leakage Cu. Ft. per Hour	Heat Loss B.t.u. per Hour 0–70 Deg. Fahr.	Sq. Ft. Radiation	Leakage Cu. Ft. per Hour	Heat Loss B.t.u. per Hour 0–70 Deg. Fahr.	Sq. Ft. Radiation	Leakage Cu. Ft. per Hour	Heat Loss B.t.u. per Hour 0–70 Deg. Fahr.	Sq. Ft. Radiation
PART I	5.0	25.0	31.5	0.13	25.5	32.1	0.13	8.1	10.2	0.04
	10.0	56.8	71.5	0.30	59.1	74.4	0.31	23.2	29.2	0.12
	15.0	88.0	110.8	0.46	92.5	116.8	0.49	39.4	49.6	0.21
Values actually determined by tests	20.0	120.4	151.8	0.63	129.7	163.4	0.68	57.5	72.4	0.30
	25.0	156.3	197.0	0.82	171.4	216.0	0.90	75.3	94.9	0.40
	30.0	192.2	242.2	1.01	213.0	268.7	1.12	95.0	119.9	0.50
	35.0	233.8	294.9	1.23	265.0	334.3	1.39	118.1	148.8	0.62
PART II	5.0	20.4	25.7	0.10	20.4	25.7	0.10	6.5	8.2	0.03
	10.0	45.4	57.2	0.24	47.3	59.6	0.25	18.6	23.4	0.10
Values for practical use; average test values reduced by 20 per cent to allow for building up of pressure in room, etc.	15.0	70.4	88.6	0.37	74.0	93.1	0.39	31.5	39.7	0.17
	20.0	96.3	121.2	0.51	103.8	130.7	0.55	46.0	57.9	0.24
	25.0	125.0	157.6	0.66	137.1	172.8	0.72	60.2	75.8	0.32
	30.0	153.8	193.4	0.81	170.4	215.0	0.90	76.0	95.6	0.40
	35.0	186.8	236.0	0.98	212.0	267.5	1.11	94.5	119.0	0.50

TABLE 17. INFILTRATION THROUGH VARIOUS TYPES OF WALL CONSTRUCTION

	Wind Velocity Miles per Hour	8½ in. Brick Wall			8½ in. Brick Wall Plastered			13 in. Brick Wall			13 in. Brick Wall Plastered			Frame Wall Without Lath and Plaster			Frame Wall With Lath and Plaster		
		Leakage Cu. Ft. per Sq. Ft. per Hour	B.t.u. per Hour per Sq. Ft. 0-70°F.	Radiation Sq. Ft. per 100 Sq. Ft. of Wall Area	Leakage Cu. Ft. per Sq. Ft. per Hour	B.t.u. per Hour per Sq. Ft. 0-70°F.	Radiation Sq. Ft. per 100 Sq. Ft. of Wall Area	Leakage Cu. Ft. per Sq. Ft. per Hour	B.t.u. per Hour per Sq. Ft. 0-70°F.	Radiation Sq. Ft. per 100 Sq. Ft. of Wall Area	Leakage Cu. Ft. per Sq. Ft. per Hour	B.t.u. per Hour per Sq. Ft. 0-70°F.	Radiation Sq. Ft. per 100 Sq. Ft. of Wall Area	Leakage Cu. Ft. per Sq. Ft. per Hour	B.t.u. per Hour per Sq. Ft. 0-70°F.	Radiation Sq. Ft. per 100 Sq. Ft. of Wall Area	Leakage Cu. Ft. per Sq. Ft. per Hour	B.t.u. per Hour per Sq. Ft. 0-70°F.	Radiation Sq. Ft. per 100 Sq. Ft. of Wall Area
PART I	5.0	2.18	2.75	1.15	0.021	0.026	0.011	1.80	2.27	0.945	0.006	0.008	0.003	5.50	6.93	2.88	0.102	0.138	0.057
	10.0	5.24	6.60	2.75	0.046	0.058	0.024	4.90	6.19	2.58	0.16	0.020	0.008	16.00	20.20	8.40	0.270	0.340	0.141
	15.0	9.81	12.30	5.13	0.083	0.105	0.044	9.35	11.90	4.90	0.031	0.039	0.016	28.70	36.20	15.10	0.521	0.656	0.272
	20.0	15.30	19.30	8.04	0.134	0.169	0.070	14.50	18.30	7.63	0.054	0.068	0.028	45.00	56.70	23.60	0.796	1.000	0.416
Values actually determined by Laboratory tests.	25.0	23.20	29.20	12.20	0.201	0.253	0.105	20.30	25.60	10.70	0.084	0.105	0.044	60.00	75.60	31.40	1.070	1.350	0.562
	30.0	28.60	36.10	15.10	0.295	0.372	0.155	26.50	33.40	13.90	0.121	0.153	0.064	76.90	96.90	40.30	1.330	1.670	0.695
	40.0	43.50	54.80	22.80	0.543	0.685	0.285	39.80	50.20	20.90	.....	.....	.....	108.00	136.00	56.60	1.860	2.340	0.975
PART II	5.0	1.75	2.21	0.92	0.017	0.021	0.009	1.44	1.82	0.77	0.005	0.006	0.003	4.40	5.55	2.31	0.082	0.103	0.043
	10.0	4.20	5.29	2.20	0.037	0.047	0.020	3.92	4.95	2.06	0.013	0.016	0.007	12.80	16.10	6.71	0.216	0.272	0.113
	15.0	7.85	9.90	4.12	0.066	0.083	0.035	7.48	9.45	3.93	0.025	0.032	0.013	23.00	29.00	12.10	0.417	0.525	0.219
	20.0	12.20	15.40	6.41	0.107	0.135	0.056	11.60	14.60	6.10	0.043	0.054	0.022	36.00	45.40	18.90	0.637	0.802	0.334
Values for practical use; average test values reduced by 20 per cent to allow for building up of pressure in room, etc.	25.0	18.60	23.40	9.75	0.161	0.203	0.085	16.30	20.60	8.55	0.067	0.085	0.035	48.00	60.50	25.20	0.856	1.080	0.450
	30.0	22.90	28.90	12.10	0.236	0.297	0.124	21.20	26.70	11.10	0.097	0.122	0.051	61.50	77.50	32.30	1.060	1.340	0.557
	40.0	34.80	43.80	18.30	0.435	0.548	0.228	31.80	40.10	16.70	.....	.....	.....	86.40	109.00	45.30	1.490	1.880	0.783

Notes.—*A.* The values given in the above table were derived from experiments on only a few samples of both brick and frame walls, and while they may be assumed to represent average walls or average conditions there might be a wide difference in the value between well built walls of both constructions, and those not so built. Further tests are now being conducted to verify this.

B. It will be noted that the loss through plastered walls can be neglected.

TABLE 18. INFILTRATION THROUGH ROLLED SECTION STEEL WINDOWS

Per Foot of Crack of Ventilating Sash

	Wind Velocity Miles per Hour	Industrial Pivoted 1/8 in. Crack			Architectural Projected 1/4 in. Crack			Residential Casement 1/8 in. Crack			Heavy Casement Section Projected 1/8 in. Crack		
		Leakage Cu. Ft. per Hour	Heat Loss B.t.u. per Hour 0-70°F.	Sq. Ft. Radiation	Leakage Cu. Ft. per Hour	Heat Loss B.t.u. per Hour 0-70°F.	Sq. Ft. Radiation	Leakage Cu. Ft. per Hour	Heat Loss B.t.u. per Hour 0-70°F.	Sq. Ft. Radiation	Leakage Cu. Ft. per Hour	Heat Loss B.t.u. per Hour 0-70°F.	Sq. Ft. Radiation
PART I	5	65	82	0.34	25	32	0.13	17	21	0.09	10	13	0.05
Values actually determined by Laboratory tests.	10	135	170	0.71	65	82	0.34	40	50	0.21	30	38	0.16
	15	220	278	1.16	110	139	0.58	65	82	0.34	47	59	0.25
	20	305	384	1.60	145	183	0.76	95	120	0.50	68	86	0.36
	25	380	479	2.00	190	239	1.00	125	158	0.66	90	113	0.47
	30	465	586	2.44	260	328	1.37	160	202	0.84	120	151	0.63
PART II	5	52	66	0.27	20	26	0.10	14	17	0.07	8	10	0.04
Values for practical use; test values reduced 20 per cent to allow for building up of pressure in room, etc.	10	108	136	0.57	52	66	0.27	32	40	0.17	24	30	0.13
	15	176	222	0.93	88	111	0.46	52	66	0.27	38	47	0.20
	20	244	307	1.28	116	146	0.61	76	96	0.40	54	69	0.29
	25	304	383	1.60	152	191	0.80	100	126	0.53	72	90	0.38
	30	372	469	1.95	208	262	1.10	128	162	0.67	96	121	0.50

Note.—With reasonable care in installation, leakage at contacts where windows are attached to steel framework, and at mullions, is negligible. With ¼ in. crack, representing poor installation, leakage at contact with steel framework is about one-third, and at mullions about one-sixth, of that given for industrial pivoted windows above.

TABLE 19. INFILTRATION THROUGH A HOLLOW METAL VERTICALLY PIVOTED STEEL WINDOW, INSTALLED IN A BUILDING

Wind Velocity Miles per Hour	Leakage Cu. Ft. per Hour per Foot of Crack	Heat Loss B.t.u. per Hour 0-70 Deg. Fahr.	Square Foot Radiation
5	29.5	37	0.15
10	88.5	112	0.47
15	144.5	182	0.76
20	186.0	234	0.98
25	221.5	279	1.16
30	242.0	305	1.27

containing the same values reduced by 20 per cent in accordance with the suggestion of the authors.

According to the authors of the papers: "The values given in the tables are from the tests as made and are probably somewhat higher than those actually found in practice. They represent the leakage when the pressure drop through the window is a certain value which represents a definite wind velocity at right angles to the window. If the wind strikes the window at an oblique angle the component of the velocity at right angles to the window must be considered. Pressure difference between the outside and the inside surfaces of the window for an actual wind will be slightly less for a given velocity because of a building up of pressure within the room before the air leaks out the opposite side of the building. Attention is called to the fact that air leaks in on the windward side of the building and out on the leeward side and, since wind will blow from various directions at different times, heating for any room having only one exposure must be based on the maximum loss. The heating plant, however, need not be figured on the sum of all maximum leakages, but in general only half of the total. However, the table gives accurate comparative figures which are probably not much too high for actual practice. In order to apply these values, a further study of the overall results as found in practice should be made, and the figures modified, if necessary, to fit practical conditions."

In their discussion of results on tests of double-hung wood sash windows as presented in the TRANSACTIONS, A. S. H. & V. E., Vol. 30, 1924, p. 313, the authors state:

"The principal facts brought out in the first report were that increasing the crack around the perimeter of a plain sash did not materially increase the leakage, and that weatherstripped sash, while permitting much less leakage, showed a small increase in leakage with increase in crack. These facts were established by making several hundred tests. The present report deals with the effect of increasing the width of the stile, that is, increasing the clearance.

"Fig. 5 illustrates what is meant by crack and clearance. The crack around the sash perimeter is equal to one half the difference between the width of the frame and the width of the sash, that is, the crack is the same on each side of the sash. The clearance is the difference between the width of the stile and the thickness of the sash. These terms are chosen arbitrarily to distinguish the two principal air passages which are found in double-hung windows.

"Four sets of sash were fitted with cracks of 1/16, 1/8, 3/16 and 1/4 in. Each set was tested with clearances varying from 1/32 to 1/4 in. Each test was repeated a number of times because no two tests gave exactly the same leakage, and it was necessary to obtain average results. Before duplicating any test the window was opened and closed, and the stops were removed and then returned to as nearly the same position as possible. The weatherstripped sashes were tested in the same way.

"Fig. 6 gives the results of tests on a plain wood window with various clearances. The tests proved that the size of the crack around the perimeter of the sash has no appreciable effect on the leakage. Therefore the results apply to any window of the type tested with a crack

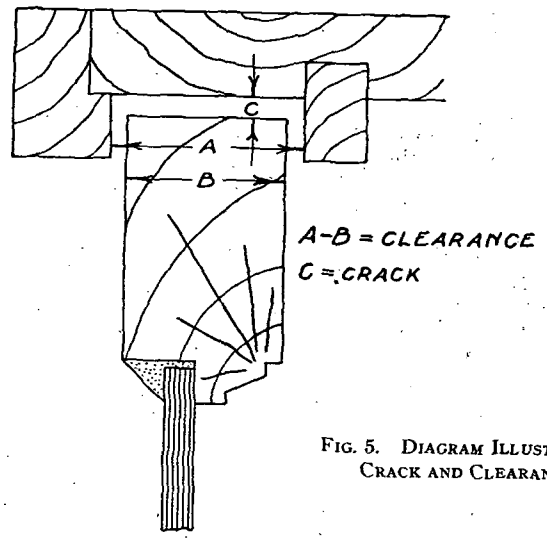


FIG. 5. DIAGRAM ILLUSTRATING CRACK AND CLEARANCE

of from 1/16 to 1/4 in. In practice most new sashes are fitted with the crack at least 1/16 in., and this crack becomes greater as the sash dries out and shrinks. It should be clearly understood that each curve is the average obtained from a number of tests, and the results of any one test may vary from the given curve by four or five per cent. The figure shows that the leakage increases rapidly with increase in clearance for plain wood windows."

This same report shows that for windows equipped with the better type of weatherstripping there is only a 15 per cent increase in air leakage for an increase in clearance from 1/16 to 1/4 in. Tests to date have shown no consistent results on the effect of locking plain double-hung wood windows. Some tests show a decrease and others even show an increase in infiltration. The authors in discussing the results of the St. Louis double-hung metal sash window tests state that the infiltration loss through such metal windows can be reduced about 10 per cent by locking a non-weatherstripped window; and an average additional 56 per cent by applying weatherstripping of the types studied, to the locked window.

Tables 15 and 16 show the heat losses in B.t.u.'s per hour per foot of crack for plain windows and weatherstripped windows to heat the incoming air from 0 to 70 deg. fahr. The tables also show the radiation in square feet that must be installed to take care of these heat losses. This radiation is based on a heat emission factor of 240 B.t.u. per square foot.

For example, consider a double-hung window at a wind velocity of 15 miles per hour. For a plain non-stripped window, Table 15 shows

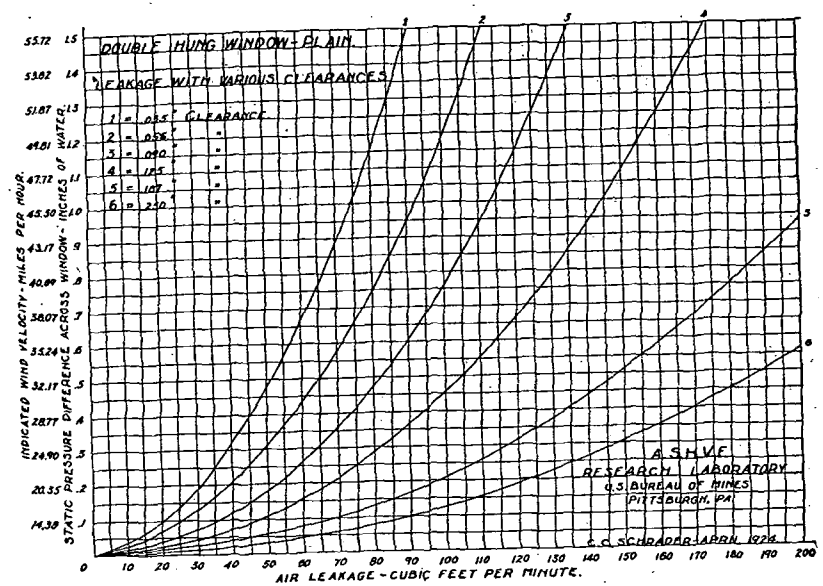


FIG. 6. LEAKAGE THROUGH PLAIN WOOD WINDOW WITH VARIOUS CLEARANCES

Note.—The above curves show the leakage for the total crack. To obtain the leakage in cubic feet per hour per foot of crack, multiply by 60 and divide by 18.25.

that 0.65 sq. ft. of radiation is required to take care of the infiltration loss per foot of crack. This table shows for the weatherstripped window, a corresponding radiation requirement of 0.12 sq. ft. per foot of crack, indicating that the application of good weatherstripping has brought about a reduction of 0.53 sq. ft. in the radiation required per foot of crack.

Assuming the heating system costs $2.00 per square foot of radiation installed and weatherstripping to cost $0.30 per lineal foot installed, there would result for each $0.30 invested in weatherstripping, a reduction of $1.06 in the initial cost of the heating system. For any particular installation the costs applying to that locality and for that particular type of construction should be used in making such a cost analysis. No attempt is made here to figure the reduction in operating cost due to the application of weatherstripping, as this varies greatly depending on how the plant is operated.

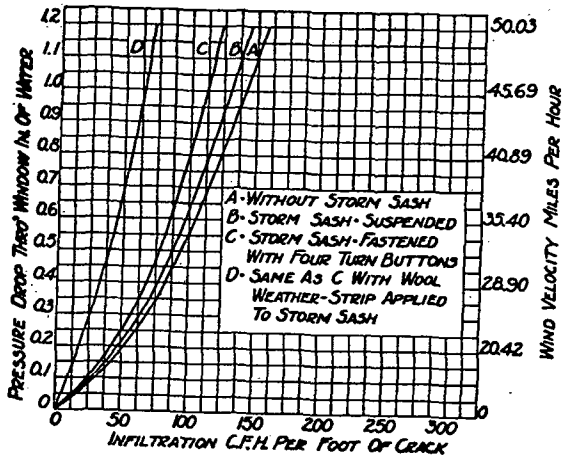


Fig. 7. Infiltration through Sash Perimeter of Window with and without Storm Sash—$\frac{5}{64}$ in. Crack and $\frac{1}{32}$ in. Clearance

Figs. 7 and 8 show the results of tests that were made at the University of Wisconsin to establish the value of storm sash for reducing infiltration. While the tests were made on storm sash only, the results and conclusions would no doubt also apply to storm doors.

Fig. 7 shows the results of the application of storm sash to a tight window and Fig. 8 shows the application of storm sash to a loose window.

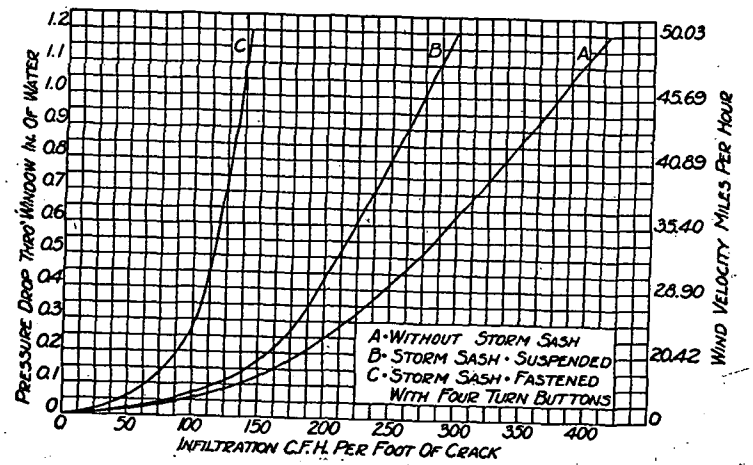


Fig. 8. Infiltration through Sash Perimeter of Window with and without Storm Sash—$\frac{1}{8}$ in. Crack and $\frac{1}{8}$ in. Clearance

A study of these curves leads to the conclusion that a storm sash is of very little value in reducing infiltration when applied to a well fitted window, but that a reduction of about 50 per cent might be expected when storm sash is securely applied to a poorly fitted or loose window. Curves B and C, Fig. 8 show that much better results are obtained by means of turn buttons on the outside than by securing the storm sash with toggle links on the inside.

Calculations for Infiltration

In order to arrive at the heat required for warming up the air entering by infiltration, the following procedure is necessary:

First, determine the average wind movement in miles per hour for the locality in question (Table 3);

Second, determine the inleakage of outside air per lineal foot of the given window or door crack in cubic feet per minute at the given wind velocity, Table 15 or 16;

Third, express the heat equivalent in B.t.u. per hour per foot of crack to heat this air 1 deg. fahr.

Thus, for a plain wood window having $\frac{1}{16}$ in. *crack* and $\frac{7}{64}$ in. *clearance* (see Fig. 5), which means the air channel around the edge of the sash is approximately $\frac{1}{16}$ in. wide, the heat equivalent of the air leaking in for a 0–70 deg. fahr. temperature difference is 157 B.t.u. per foot of crack per hour (Table 15, Part II). This value is found in the sixth column of the table. The computation for obtaining 157 is:

$$124 \times 0.075 \times 0.24 \times 70 = 157 \text{ B.t.u.,}$$

where

124 = cubic feet of air per foot of crack per hour for a 15 mile wind for $\frac{7}{64}$ in. clearance from the 5th column of Table 15.
0.075 = air density at 70 deg. fahr., pound per cubic foot.
0.24 = specific heat of air, and
70 = difference in temperature between inside and outside air.

The most convenient values for use in infiltration calculations are the coefficients of infiltration for the particular kind of crackage with a wind velocity of 15 miles per hour under average conditions, with $\frac{1}{16}$ in. *crack* and $\frac{7}{64}$ in. *clearance* reduced by 20 per cent (Table 15, Part II).

For a wind velocity other than 15 miles per hour, use the proper velocity for that locality in place of 15. For temperature gradients other than 70 deg. multiply the value given in the tables by the new temperature gradient and divide by 70. For special cases involving unplastered walls or storm sash use values obtained from Table 17 or Figs. 7 and 8.

Infiltration Due to Temperature Difference

Even without wind movement, a difference of temperature between inside and outside of a building will cause the pressure state inside to be less than that outside near the ground, and greater near the roof; infiltration will occur at windows in the lower part of the building, and exfiltration at windows in the upper part. Thus in the case of a building 200 ft. high; arranged in stories with more or less free communication

from one to another, and with a temperature difference of 70 deg., the pressure causing infiltration near the ground, and exfiltration near the roof, may easily exceed 0.20 in. of water, which is the equivalent of a twenty-mile wind.

The factors influencing the pressures causing infiltration are so numerous that it does not seem wise at this time to attempt to include any quantitative values to express the effect of temperature difference, but it is something that should be kept in mind in the design and operation of heating systems in tall buildings.

HEAT SOURCES

Heat Available from Sources other than Heating Plant

The heat supplied by persons, lights, motors and machinery should always be ascertained in the case of theaters, assembly halls, and industrial plants, but allowances for such heat sources must be made only after careful consideration of all local conditions. In many cases, these heat sources should not be allowed to affect the size of the installation at all, although they may have a marked effect on the operation and control of the system later. In general, it is safe to say that where audiences are involved, the heating installation must have sufficient capacity to bring the building up to the stipulated inside temperature before the audience arrives. In industrial plants, quite a different condition exists, and heat sources, if they are always available during the period of human occupancy, may be substituted for a portion of the heating installation. In no case should the actual heating installation (exclusive of heat sources) be reduced below that required to maintain at least 40 deg. fahr. in the building. The following allowances may be made when required:

TABLE 20. HEAT GIVEN UP BY PERSONS AND LIGHTS

*PERSONS:	
Man at rest	400 B.t.u. per hr.
Man at work	500 B.t.u. per hr.
LIGHTS:	
Electric lamps, B.t.u. per hr. equals watts per lamp × number of lamps × 3.415	
Gas lighting:	
1 cu. ft. producer gas	150 B.t.u.
1 cu. ft. illuminating gas	700 B.t.u.
1 cu. ft. natural gas	1000 B.t.u.
A Welsbach burner averages 3 cu. ft. of gas per hour and a fish tail burner 5 cu. ft. per hour.	

*For more detailed information see Table 21, Heat Emitted by Persons per Hour at Different Room Temperatures.

Motors and the machinery which they drive, if both are located in the room, convert all of the electrical energy supplied into heat, which is retained in the room if the product being manufactured is not removed until its temperature is the same as the room temperature.

If power is transmitted to the machinery from the outside, then only the heat equivalent of the brake horsepower supplied is used. In the first case the B.t.u. supplied per hour $= \frac{\text{Motor horsepower}}{\text{Efficiency of motor}} \times 2546$, and

in the second case B.t.u. per hr. = b.hp. × 2546, in which 2546 is the B.t.u. equivalent of 1 hp. hour. In high-powered mills this is the chief source of heating and is frequently sufficient to overheat the building even in zero weather, thus requiring cooling by ventilation the year round.

For intermittent heating allow 10 per cent additional for rooms heated in the day time only, and for longer intervals of several days or more, add 25 per cent in determining minimum heating requirements, and size of plant.

TABLE 21. HEAT EMITTED BY PERSONS PER HOUR AT DIFFERENT ROOM TEMPERATURES

H = Heat emitted by man at rest per hour.
Hl = Heat emitted by man at light labor per hour.
Ha = Heat emitted by man at average labor per hour.
Hh = Heat emitted by man at hard labor per hour.
HE = Heat Energy $= \left(\frac{\text{Foot-Pounds per hour}}{778}\right) =$ 84 B.t.u., 168 B.t.u. and 252 B.t.u. respectively for light, average and hard labor.
T = Room Temperature.
$H = 13.2\ (98.6 - T)$ Heat due labor $= \frac{T \times HE}{100}$
Hl, Ha, or $Hh = 13.2\ (98.6 - T)$ plus $\frac{T \times HE}{100}$

Room Temp. Deg. Fahr.	Heat Emitted by Man* B.t.u. per Hour at: Rest	84 B.t.u. Light Labor	168 B.t.u. Average Labor	252 B.t.u. Hard Labor	Condition Required to Balance Excess and Shortage in Heat Emission
30	905	931	954	981	Increasing Humidity
40	773	807	838	874	Heavy Clothing for Reduction or Prevention of Radiation
50	642	684	723	768	
60	509	559	606	660	
68	404	461	518	575	Normal Condition
70	378	436	491	554	
75	312	375	438	501	Decreasing Humidity
80	246	313	375	447	Air Currents for Producing Evaporation of Perspiration
85	180	251	322	394	
90	114	189	259	342	

*For children use one-half of table values.

Application to Factory Heating[6] (See Fig. 9)

Lowest outside temperature for Philadelphia, Pa. = −6 deg. fahr. (Table 3), hence use $(-6 + 10) = +4$ for heat loss computations. Average wind movement (Table 3) for December, January, February = 11.0 miles per hour from the Northwest. Long axis of building is north and south.

Inside breathing-line temperature = 60 deg. fahr.

Walls: 9 in. concrete (stone), ½ in. cement mortar, 2 in. tile, plastered ½ in.

K_1 = 1.34 Average for surface in still air (Table 4).
K_2 = 3 × 1.34 = 4.02 Average for surface exposed to moving air (Tables 4 and 6).
C_1 = 8.3 for stone concrete (Table 5).
C_2 = for tile as shown use 1.14 (not per 1 in.), (Table 5).
C_3 = 8.0 for cement mortar (Table 5).
C_4 = 2.32 for gypsum plaster (Table 5).

[6]In this example a design temperature only 10 deg. fahr. above lowest on record instead of 15 deg. fahr. above was used. Infiltration values were taken from Table 15 for a plain window.

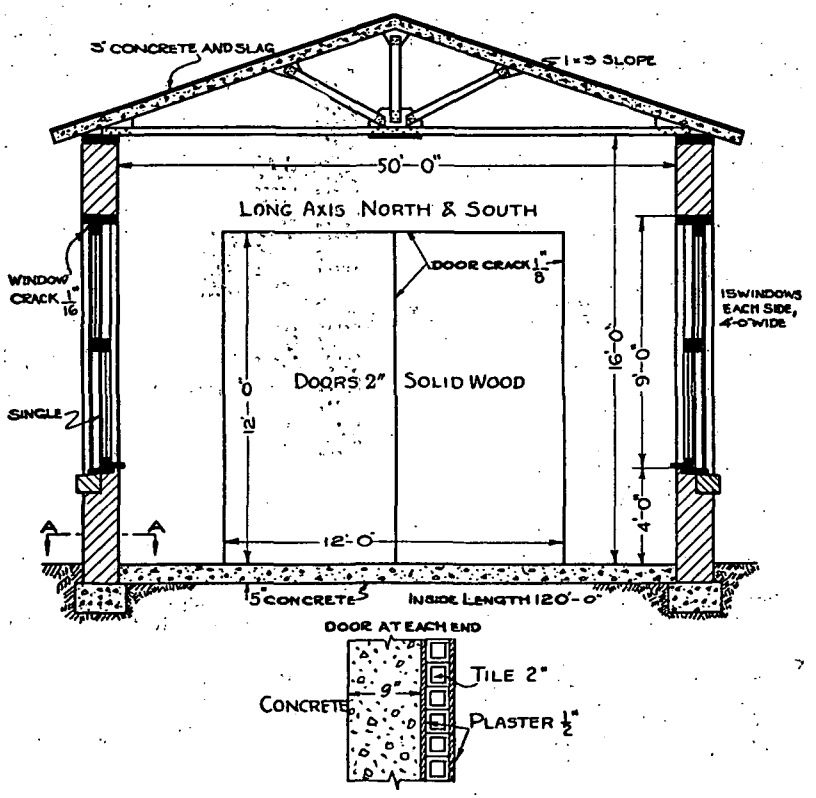


FIG. 9. ELEVATION OF FACTORY BUILDING

$$U = \frac{1}{\frac{1}{K_1} + \frac{1}{K_2} + \frac{x_1}{C_1} + \frac{x_2}{C_2} + \frac{x_3}{C_3} + \frac{x_4}{C_4}} = \frac{1}{\frac{1}{1.34} + \frac{1}{4.02} + \frac{9}{8.3} + \frac{1}{1.14} + \frac{0.5}{8.0} + \frac{0.5}{2.32}}$$

$$= 0.304$$

The air temperature at the mean height of inside walls is greater than at breathing line. Mean height of walls is $16 \div 2 = 8$ ft., which $8 - 5 = 3$ ft. above breathing line. Allowing 2 per cent per foot above 5 ft., or $2 \times 3 = 6$ per cent, makes the mean air temperature $1.06 \times 60 = 63.6$ deg. fahr. The triangular areas in the end wall are practically at the mean height of the roof at which level the air temperature is 78 deg. fahr.

Roof: 3 in. concrete (stone), with slag surface built-up roofing.

$U = 0.610$ (Roof No. 216-c, Table 11-A)

The air temperature just below roof is higher than that at the breathing line. Mean height of roof is $16 + 4 = 20$ ft., or it is $20 - 5 = 15$ ft. above breathing line. Allowing 2 per cent per foot above 5 ft., or $2 \times 15 = 30$ per cent, makes the under roof temperature $= 1.30 \times 60 = 78$ deg. fahr.

Floor: The 5 in. concrete floor is laid on the ground, and hence there is only one surface coefficient $K_1 = 1.34$ = Average for surface in still air (Table 4)

$$U = \frac{1}{\frac{1}{1.34} + \frac{5}{8.3}} = 0.745$$

The air temperature at floor level $= 60 - 5 = 55$ deg. fahr.

Windows and Doors: Wood sash and doors with single thickness of glass. Take coefficient U for glass as 1.13 B.t.u. per sq. ft. per degree per hour for heat transmission (Table 13-A). Doors are solid wood 2 in. thick and coefficient $U = 0.382$ B.t.u. per sq. ft. per degree per hour (Table 13-B).

Infiltration: Assume window crack assumed $\frac{1}{16}$ in. and doors at $\frac{1}{16}$ in. By Table 15 the proper for a 10 mile wind velocity the leakage per foot of crack is 84 be used for a plain window. The heat equivalent per hour, per degree for one

designed

$$9 \times .075 \times 0.24 = 1.53 \text{ B.t.u.}$$

and allowing for an 11 mile wind the factor becomes $1.53 \times \frac{11}{10} = 1.68$ (see preceding note). Allow twice this for door crack or $2 \times 1.68 = 3.36$.

CALCULATION SHEET

Entire Building

(See Fig. 9)

Building Material	Exposure	Width in Ft.	Height in Ft.	Area Sq. Ft. or Lin. Ft.	Coeffic. Trans. and Infilt.	Temp. Diff.	Net B.t.u.	Exposure Factor	Total B.t.u.
Concrete and Tile	N	½ × 50	8½	213	0.304	74.0	4,800	1.15	5,520
	N	50	16	656	0.304	59.6	11,850	1.15	13,630
Doors (2 in. wood)	N	12	12	144	0.382	56	3,080	1.15	3,550
⅛ in. Crack	N	1 pair doors		60	3.36	56	11,300	½* × 1.15	6,500
									29,200
Concrete and Tile	W	120	16	1380	0.304	59.6	24,950	1.15	28,700
Glass (Single)	W	15 × 4	9	540	1.13	59.6	36,200	1.15	41,600
⅛ in. Crack	W	Double Hung Windows (15)		450	1.68	59.6	44,900	½* × 1.15	25,800
									96,100
South Wall	Same as N	See above		———	———	———	———	½*	25,380
East Wall	Same as W	See above		———	———	———	———	½*	83,600
Roof, 3 in. Concrete and slag-surfaced built-up roofing	No Ceiling	52.5	120	6300	0.610	74	285,000	None	285,000
Floor, 5 in. Stone Concrete	On Dirt	50	120	6000	0.745	5	22,350	None	22,350

Grand total of heat required for building in B.t.u. per hour at + 4 deg. with 11-mile Southwest wind 541,630

*Notes.—(1) This building has no partitions and whatever air enters through the cracks on the wind-

ward side must leave through the cracks on the leeward side. Therefore, only one-half of the total crack will be used in computing infiltration for each side and each end of building.

(2) An exposure allowance of 15 per cent is also to be added to the wall and glass transmission losses and to the infiltration losses on the two adjacent sides of the building most nearly facing the prevailing wind as stated in the first paragraph on page 48.

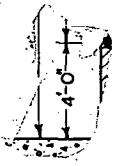
(3) It is also possible to compute the heat required to take care of infiltration on the basis of ½ of an air change per hour as given in Table 14 for a factory with minimum conditions. Volume = 50 × 120 × 20 (mean height) = 120,000 cu. ft. and heat required per hour is

$$120{,}000 \times \tfrac{1}{2} \times 0.075 \times 0.24 \times 59.6 = 64{,}200 \text{ B.t.u.}$$

Based on infiltration through one-half the total crackage in all walls, the heat to be supplied per hour is from preceding table,

$$6{,}850 + 27{,}300 + 5{,}950 + 23{,}750 = 63{,}850 \text{ B.t.u.}$$

This value based on crackage should be used, but if building is to be heated intermittently, not less than one air change per hour should be allowed.



CHAPTER II

RADIATORS AND HEATERS

Kinds of Heat Emitting Units, Heat Emission from Different Kinds of Radiators and Heaters, Effects of Humidity, Painting and Enclosures on Heat Emission, Specifications for Cast Iron Radiators.

THIS chapter is intended to apply to the salient data on the different kinds of heating elements pertaining to that field wherein heating is done by direct radiators, direct-indirect or concealed heaters (performing their function of emitting the necessary heat by radiation or conduction) or wherein the heating is done by concealed built-in heaters, cabinet heaters or indirect heaters, performing these same functions, mainly by the processes of convection.

It should be understood that any heater, whether it be a cast-iron "radiator" or one of the newer non-ferric, extended surface heaters specifically designed for enclosure within a wall or cabinet, heats the air which comes in contact with its surfaces almost wholly by *conduction*, the radiant effect being negligible.

Careless nomenclature has resulted in such confusion that the facts should be briefly reviewed.

An exposed cast-iron radiator emits from 10 per cent to, almost, 30 per cent of its heat emission, as radiant heat.[1] The balance or major position of its emission is, of course, by conduction to the air in contact with the heated surfaces. Thereupon the heated air, through convection, sets up a circulation which tends to distribute the heat, more or less uniformly, in accordance with the manner in which the convection currents are utilized.

When a cast-iron radiator, or one of the newer non-radiating heaters provided with extended conducting surfaces, is enclosed within a wall or cabinet, it emits practically no heat by radiation, functioning as a "conductor" rather than a "radiator." Hence the term "radiator" or "radiation" applied to such heaters, or such *heat-surface*, is distinctly a misnomer which should not be perpetuated. And it should be equally emphasized that air is heated by *conduction*, in contact with a heated surface, while *convection* is that phenomenon by which heat is distributed within a *fluid*, liquid or gas. With these facts kept in mind there should be no further confusion or faulty nomenclature.

Most of the former types of large column cast-iron radiators have recently been replaced by the small tube types, while many forms of concealed and cabinet heaters have recently been developed. These changes make it necessary to establish definite meanings for the terms

[1]Research Laboratory, AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS.

Material for this Chapter prepared especially for THE GUIDE by the following committee: Prof. A. P. Kratz, *chairman;* Esten Bolling, Dr. C. W. Brabbée, J. F. McIntire, F. D. Mensing and R. N. Trane.

which shall be used for designating the different kinds of heat emitting units as follows:

Direct Radiators are heaters which are placed directly in the room or space to be heated and impart their heat to the objects and air in this space by direct radiation, and conduction, the air then distributing the heat by convection.

Indirect Heaters are those placed outside of the room or space to be heated and so arranged as to impart their heat to air, which is passed over the surface and thence delivered to the room, without imparting any material amount of heat to the room by direct radiation. Indirect heaters are generally so designated where the movement of air over them is by gravity. When the movement of the air is by fan or other mechanical means, this type of heater is designated as blast heater, stacks or coils.

Concealed Radiators are those placed within or immediately adjoining the room or space to be heated, but separated by an enclosure, or other means, so as to be substantially hidden except for the openings or grilles for air circulation. They may have grilles over the entire front or at top and bottom only.

Recessed Radiators are those placed in a recess in the walls or partitions of the space to be heated. They may be either wholly or partially covered by grilles and thus become concealed, but it is recommended that the designation *concealed radiators* be used in such cases and that the term *recessed radiators* be confined to those set in open recesses.

Built-in or Concealed Heaters are concealed heat emitting units especially designed to be built into the walls or partitions of the space to be heated and deliver the bulk of the heat to this space by the processes of convection.

Cabinet Heaters are special heat emitting units designed for and enclosed in a cabinet to be exposed in the space to be heated. Ordinary radiators may be placed in cabinets but should be designated as radiators in cabinets.

Semi-Indirect Radiators is an indefinite term which is more or less obsolete and should be discarded in favor of the more definite terms referred to previously. It originally referred to such as the concealed, built-in or cabinet types.

Direct-Indirect Radiators are radiators designed to be set exposed in the space to be heated but equipped with integral flues, dampers and connections for taking air from the outside, from the room or both and delivering its heat and some fresh air by this means to the room.

Most of these types of radiators and heaters may be made of pipes, in which case they are spoken of as pipe coils. The other heaters are usually made from cast-iron or non-ferrous metals. Cast-iron radiators are used as column, wall, or window radiators, and in all three cases the original large columns have recently been replaced by small tubes, in a great variety of forms, for which no standard technical data are available at present. As a result of this great diversity of design and lack of engineering data, a condition has developed which an attempt has been made to meet by establishing a Code for Testing Radiators.[2]

In the past the unit of measure recognized in computing the heat emission was *square feet of heating surface*, which is rapidly being discarded, however, for the reason that the heat emission depends upon the design of the radiator as well as its surface area. The engineer is interested primarily in the amount of heat emitted rather than in the amount of surface in a radiator or heater. As a result, radiators or heaters are being rated on the amount of total heat given, either in B.t.u. per hour or in equivalent square feet based on 240 B.t.u. per hour.

[2]At a meeting of the Committee on Research of the AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS at New York, January 23, 1928, the following resolution was adopted:

That all manufacturers of radiators be requested by the Committee on Research to publish the ratings of their product in British heat units. Their ratings are to be certified and guaranteed, and for the present at least, are to be based on condensation performance, determined in accordance with the tentative Code of the AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS for testing radiators.

Recently a new development in heating practice has taken place. The effect of radiators for house heating purposes is not alone for heating up the building, but rather to obtain and secure comfort for the occupants. In this connection it cannot be denied that comfort feeling for human beings in winter calls for the delivery of warmth in the lower part of the room, in the zone of occupancy, instead of overheating the ceiling, in which latter case, a considerable amount of heat can be wasted. These investigations, the goal of which is to determine the useful heat output of a radiator or heater instead of its total output (by condensation) are still under way.[3]

This scheme of heating the zone of occupancy may be accomplished by radiators especially designed to give off the greater part of their heat by radiation, rather than by conduction, so that when such radiators are placed directly opposite the place of occupancy of a room most of the heat is projected out directly in this plane without unduly heating the air in the upper part of the room.

Another method for accomplishing the same result lies in the proper use and application of the principles of concealed and cabinet heaters, whereby the heat is transferred to the room by means of heated air continuously projected out in the plane of occupancy of the room and replaced by an equal volume of cooler air drawn into the base of the heater from near the floor, thus creating a local circulation within the zone of occupancy and tending to prevent overheating of the air in the upper part of the room.

TOTAL HEAT EMISSION OF CAST IRON RADIATORS

Tube radiators are not yet standardized, and it is, therefore, impossible to give standard data. Also, under the present ruling of the Committee on Research, as stated on page 66, the only recourse at present seems to be to refer to the various makers' catalogs and accept the ratings as given. However, sufficient radiation is being calculated on the old basis to warrant the inclusion of a condensed table of heat emission based on the actual number of square feet of surface presented by various types of column radiators. Table 1 has been condensed from the AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS Research Laboratory Standard Data, prepared in cooperation with the U. S. Bureau of Mines at the Pittsburgh Experiment Station, and gives the heat emission per square foot for the standard steam temperature of 215 deg. fahr. and room temperature of 70 deg. fahr. The original tables were given in a report of the Research Laboratory,[4] resulting from experiments by John R. Allen and F. B. Rowley.

Table 2 gives the heat emission of various standard types of coil radiation for steam temperature at 215 deg. fahr. and room temperature at 70 deg. fahr.

Table 3 gives the conversion factors for determining the heat emission

[3]See JOURNAL of AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS, November 1925, November 1926, June 1927, January 1928, and also Heating and Ventilation, Rietschel-Brabbée, pp. 45 to 66, and 81 to 82.

[4]Direct Radiation Tables by F. Paul Anderson, F. C. Houghten, Louis Ebin, JOURNAL of AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS, December, 1921.

for any radiator with steam or water at temperatures other than 215 deg. fahr. and with room temperatures other than 70 deg. fahr., when the emission for 215 deg. fahr. and 70 deg. fahr. are known. These factors have been based on the method outlined in the Report of the Advisory Committee on Radiation, JOURNAL of the AMERICAN SOCIETY OF HEATING

TABLE 1.* HEAT EMITTED BY DIRECT RADIATION

Steam Temperature 215 deg. fahr. Room Temperature 70 deg. fahr.

TYPE	NO. OF COLUMNS	HEIGHT INCHES	RATED SURFACE PER SECTION SQ. FT.	B.T.U. PER SQ. FT. PER HOUR	
				Intermediate Section	End Section
Standard	1	38	3.00	243	375
"	1	32	2.50	250	380
"	1	26	2.00	257	385
"	1	23	1.66	266	394
"	1	20	1.50	263	395
"	2	45	5.00	217	378
"	2	38	4.00	225	396
"	2	32	3.33	233	400
"	2	26	2.66	240	413
"	2	23	2.33	242	415
"	2	20	2.00	246	411
"	3	45	6.00	206	374
"	3	38	5.00	211	380
"	3	32	4.50	215	370
"	3	26	3.75	219	366
"	3	22	3.00	226	380
"	3	18	2.25	236	390
"	4	45	10.00	191	309
"	4	38	8.00	198	321
"	4	32	6.50	207	333
"	4	26	5.00	216	346
"	4	22	4.00	222	358
"	4	18	3.00	233	375
Hospital	2	45	5.00	230	393
"	2	38	4.00	240	407
"	2	32	3.33	250	418
"	2	26	2.66	256	423
"	2	23	2.33	261	428
"	2	20	2.00	265	430
Wall	....	29	9.00	289	316
"	....	22	7.00	293	319
"	....	17	5.00	310	331
Window	....	20	5.00	211	342
"	....	16	3.75	.....	.....
"	....	13	3.00	226	361

*Condensed from Research Laboratory Standard Data—AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS—Result of Cooperative Work with U. S. Bureau of Mines Experiment Station, Pittsburgh, Pa. Copyright 1921.

AND VENTILATING ENGINEERS, March 1927, making use of the relation that the heat outputs vary as the 1.3 power of the temperature ranges.

In order to convert the heat emission from steam radiation with steam at 215 deg. fahr. and room temperature at 70 deg. fahr. to heat emission from hot-water radiation with mean water temperature at 170 deg. fahr. and room temperature at 70 deg. fahr., the heat emission from the steam radiation should be multiplied by the factor, 0.617.

TABLE 2. HEAT EMISSION OF DIRECT PIPE COIL RADIATION FOR STEAM

Steam Temperature 215 deg. fahr. Room Temperature 70 deg. fahr.

WALL COILS—COILS PLACED VERTICAL—PIPES HORIZONTAL

B.t.u. per Lineal Feet of Coil per Hour (Not Lineal Feet of Pipe)

SIZE OF COIL	1"	1¼"	1½"
Single Row	132	155	185
Two	252	312	348
Four	440	545	616
Six	567	702	793
Eight	651	796	907
Ten	732	907	1020
Twelve	812	1005	1135

WALL COILS—COILS PLACED VERTICAL—PIPES VERTICAL

Emission varies in inverse ratio of the height of the coil

Use 100 B.t.u. per lineal feet of pipe as an average for 1¼ in. coil, 10 ft. high.

CEILING COILS—COILS PLACED HORIZONTALLY—PIPES HORIZONTAL

Emission is equal to that of a single row coil

Allowance must be made, however, if the coil is at the ceiling in a higher temperature. In this case use:

126 B.t.u. per lineal feet of pipe for 1 in. coils.
146 B.t.u. per lineal feet of pipe for 1¼ in. coils.
175 B.t.u. per lineal feet of pipe for 1½ in. coils.

Table 2 has been developed by a method of deduction from the available data on such experimental work on pipe coils as has been recorded, and does not represent definite results of tests as in Table 1. The values are, therefore, approximately only, but can be used with assurance that they are more accurate than those obtained by the usual method for calculating pipe coil surface.

EXTENDED SURFACE HEATERS

Extended surface heaters in general, consist of one or more steam-carrying tubes or spaces to which the fins or sheets of extended surface are attached. The heating elements in themselves are not generally complete and require a duct, stack or chimney in order to give satisfactory results.

There are heating elements, however, of this type which are complete within themselves, and most other such units are now assembled in accompanying casings to form a complete unit, known either as a heat cabinet, a concealed heater or some appropriate name.

When installed between the walls of a building a sheet metal stack is used between the inlet and the outlet. When the heater is installed in the room it is equipped with a closely fitting box or cabinet which takes place of the stack and gives the necessary chimney effect.

The heating elements are made of brass, copper, aluminum or other highly conductive non-ferrous metal, generally with extended surfaces ranging from about 3½ x 6 in. to 4 x 8 in. in size and from 0.002 to

Table 3. Heat Emitted by Direct Cast Iron Radiation—Conversion Factors

Steam Pressure		Temp. of Steam in Deg. Fahr.	Temperature of Room					
Vacuum In. Hg.	Lb. Absolute		80 deg. fahr.	75 deg. fahr.	70 deg. fahr.	65 deg. fahr.	60 deg. fahr.	50 deg. fahr.
23.4	3.71	150	0.388	0.424	0.462	0.499	0.538	0.617
19.7	4.75	160	0.462	0.499	0.538	0.577	0.617	0.697
15.3	5.99	170	0.538	0.577	0.617	0.657	0.697	0.782
12.3	7.51	180	0.617	0.657	0.697	0.740	0.782	0.868
8.7	9.33	190	0.697	0.740	0.782	0.825	0.868	0.955
6.5	11.52	200	0.782	0.825	0.868	0.911	0.955	1.045
Lb. Gage								
1	15.7	215	0.911	0.955	1.000	1.045	1.091	1.183
2	16.8	219	0.947	0.991	1.036	1.081	1.128	1.220
3	17.8	222	0.973	1.018	1.063	1.109	1.155	1.249
4	18.9	225	1.000	1.045	1.091	1.137	1.183	1.277
5	19.6	227	1.018	1.063	1.109	1.155	1.202	1.296
6	20.8	230	1.045	1.091	1.137	1.183	1.230	1.325
8	22.8	235	1.091	1.137	1.183	1.230	1.277	1.373
10	24.9	240	1.137	1.183	1.230	1.277	1.325	1.421

These conversion factors multiplied by the heat emitted by a radiator operating at 215 deg. fahr. in a room at 70 deg. fahr., give the heat emitted by a radiator operating under the indicated conditions.

0.003 in. in thickness. These plates are spaced from 1/16 to ⅛ in. apart and the whole assembly forms a heating element from 3½ to 4 in. in width by from 6 to 8 in. high for building into 4-in. stud partition walls; or when turned in the other position, from 6 to 8 in. wide by from 3½ to 4 in. high for building into wider stud partitions. These heating elements are usually made in heights ranging from 12 in. to several feet, in 4 to 6-in. increments.

Steam or hot water is passed through the tubes in the heater and the heat is carried by conduction into the extended surface which in turn gives up the heat by conduction to the air coming in contact with the fins or plates. This heated air rises in the stack under the action of gravity circulation, the cold air coming in at the inlet near the floor and the warm air leaving at an outlet near the top. A tight-fitting damper is frequently used to control the flow of air and to limit the heat output of the heater. In any event, whether installed in a stack or cabinet, it is important to note that, within limits, the steam condensing capacity of the heater is increased as the stack height is increased, and that in order to secure proper results the stack or cabinet should fit the heater snugly so that all air, which comes through the outlet, must have been brought into contact with the fins of the heater. The limiting height for a stack in the average room is approximately 60 in., since with higher stacks there is a possibility for stratification near the ceiling, resulting in cold floors. When installed in an outside or exposed wall the stack should be well heat insulated.

These heaters may be used with both steam or hot-water heating systems, and are rated in B.t.u. emission under specified conditions or in terms of direct radiation based on 240 B.t.u. per square foot. No independent research data are available on the performance of such heaters and the only course open at present is to use the ratings in the published literature of the makers.

The performance on hot water must be determined by test since the conversion factors in Table 3 cannot be considered applicable under these conditions, although it is probable that if water with a mean temperature of 215 deg. fahr. is used the performance will be the same as when steam at the same temperature is used.

CAST IRON GRAVITY INDIRECT RADIATORS

Table 4 gives the cubic feet of air per hour (measured at 70 deg. fahr.) usually allowed per square foot of heating surface, through cast-iron gravity indirect radiators.

Table 4. Cubic Feet of Air per Hour per Square Foot of Heating Surface for Cast Iron Gravity Indirect Radiators

Indirect heaters supplying 1st floor registers	150 cu. ft. per hour
Indirect heaters supplying registers 7 ft. above first floor	200 cu. ft. per hour
Indirect heaters supplying 2nd floor registers	300 cu. ft. per hour
Indirect heaters supplying 3rd floor registers	350 cu. ft. per hour

Table 5 gives the final temperature of the air leaving cast-iron gravity indirect radiators corresponding to different entering temperatures and different cubic feet of air per hour per square foot of surface.

TABLE 5. FINAL TEMPERATURE OF AIR LEAVING ¾ IN. PIN, CAST-IRON, GRAVITY INDIRECT RADIATORS

Temperature Entering Air Deg. Fahr.	Cubic Feet of Air (at 70 deg.) per Hour per Square Foot Radiation												
	50	*75*	*100*	*125*	*150*	*175*	*200*	*225*	*250*	*275*	*300*	*325*	*350*
−10	132	130	128	126	123	121	119	116	113	111	108	105	103
0	136	134	132	130	127	125	123	120	117	115	112	109	107
10	140	138	136	134	131	129	127	124	121	119	116	113	111
20	144	142	140	138	135	133	131	128	125	123	120	117	115
30	148	146	144	142	139	137	135	132	129	127	124	121	119
40	152	150	148	146	143	141	139	136	133	131	128	125	123
50	156	154	152	150	147	145	143	140	137	135	132	129	127
60	160	158	156	154	151	149	147	144	141	139	136	133	131
	1st Floor →							2nd Floor →				3rd Floor →	

Note.—Temperature of air entering room shall be assumed lower than temperature of air leaving radiator as follows: 1st Floor 5 deg. lower, 2nd Floor 8 deg. lower, 3rd Floor, 10 deg. lower.

Table 5 is for ¾ in. pin-type radiation using steam at 1 lb. pressure. For 1 in. pin-type the temperature rise of the air is about 95 per cent of the corresponding rise for ¾ in. pin-type and for hot water at 170 deg. fahr. the temperature rise of the air ranges from 80 to 85 per cent of the corresponding temperature rises with steam at 1 lb. pressure.

From Tables 4 and 5 the heat emission of an indirect radiator may be calculated as follows:

Example.—Determine the B.t.u. transmitted per hour per square foot of surface, from a ¾ in. pin-type cast-iron radiator, supplying a first floor register; entering air at 0 deg. and steam at 1 lb. pressure.

Solution.—From Table 4, it will be found that 150 cu. ft. of air will flow per hour per square foot and from Table 5 it is determined that the final temperature of the air is 127 deg. The temperature rise of the air = 127 − 0 = 127 deg. and the B.t.u. transmitted per hour per square foot = $\frac{150}{13.35} \times 0.24 \times 127 = 333$,

where

0.24 = B.t.u. required to heat 1 lb. of air 1 deg.
13.35 = cubic feet of air per pound at 70 deg.

For a 1 in. pin-type radiator the transmission will be 333 × 0.95 = 316 B.t.u. per square foot per hour and with water at 170 deg. the transmission in either case would be 84 per cent of the respective figures for steam.

For performance data on radiators and heaters where air is forced through them by fans see Chapter XXIV.

LOCATION AND SELECTION OF CAST IRON RADIATORS

It should be made a rule to install radiators beneath or near the space of greatest heat loss. The best place is underneath an outside window. This seems logical for the following reasons:

1. Heat emitted by radiation from the radiator will counteract the effect of heat radiated out through the window from occupants in the room.

2. Cold air leaking in through the window is warmed before it reaches the interior of the room.

3. Air currents from the radiators pass upward, mingling with the cold infiltering air, and form a screen of warm air protecting against cold window drafts.

4. There is less discoloration of walls from dust arising from the radiator.

If the heater cannot be placed underneath the window, then it should be located as near the window as possible, near outside doors, underneath skylights, near to very exposed walls or corners, etc.

Heat emission by a radiator at the ceiling or floor will differ little, provided the surrounding air and objects are at the same temperature. The effect on heating the room or on temperature distribution in the room, however, may be very great. Heat applied near the ceiling will tend to stratify, resulting in a hot ceiling and cold floor, unless there is mechanical disturbance to produce circulation.

As the total heat emitted from the radiator varies with type, height, width, length, steam pressure, etc., the selection of the heater should be done in the following way:

1. Figure the total heat loss of the room as outlined in Chapter I, making proper allowances for exposure, wind velocity, height of ceiling, etc.

2. Next, decide upon the type (design, height, width, etc.) and the number of radiators to be used. Then find in Tables 1 to 3, or in tables of guaranteed performance published by the various manufacturers, the number of sections necessary for each radiator.

Example.—The heat loss from a given room calculated in accordance with Chapter I is estimated to be 14,200 B.t.u. per hour. How many sections are required in a three-column, 38-in., radiator for heating this room?

Solution.—Table 1 indicates that a 3-column, 38-in. radiator emits 211 B.t.u. per square foot per hour for intermediate sections, and 380 B.t.u. per square foot per hour for end sections. Each section has 5 sq. ft. of area. Intermediate sections will emit 5 × 211 = 1055 and each end section will emit 2½ × 211 + 2½ × 380 or 1277.5 B.t.u. per section per hour. The two end sections will emit 2 × 1277.5 = 2555, leaving 14,200 − 2555 = 11,645 B.t.u. per hour to be supplied by the intermediate sections. 11,645 ÷ 1055 = 11. Hence, 11 intermediate and 2 end sections, or a total of 12 sections, will be required.

Example.—How many sections of 5-tube radiation are required to heat a room having an estimated heat loss of 15,000 B.t.u. per hour?

Solution.—Total radiation required under the new ratings is 15,000 ÷ 240 = 62.5 sq. ft. Select the radiator from the manufacturer's catalog.

Example.—How many square feet of radiation are required to heat a room having a heat loss of 15,000 B.t.u. per hour if the pressure of the steam in the radiator is 2 lb. gage and the room temperature is 50 deg. fahr.?

Solution.—The factor from Table 3 for 2 lb. gage and 50 deg. fahr. room temperature is 1.220. Under these conditions 1 sq. ft. will emit 240 × 1.220 = 293 B.t.u. per hour. The number of square feet required is 15,000 ÷ 293 = 51.2. Select from a manufacturer's catalog.

Example.—How many square feet of hot-water radiation are required to heat a room having a heat loss of 15,000 B.t.u. per hour if the mean water temperature is 170 deg. fahr. and the room temperature is 70 deg. fahr.

Solution.—The factor from Table 3 for a temperature of 170 deg. fahr. in the radiator and a room temperature of 70 deg. fahr. is 0.617. Under these conditions 1 sq. ft. will emit 240 × 0.617 = 148 B.t.u. per hour. The number of square feet required is 15,000 ÷ 148 = 101.3. Select from a manufacturer's catalog.

PROPORTIONATE RADIATION FOR VARIOUS ROOM TEMPERATURES

Table 6, based on one given in the paper, The Establishment of Standard Methods of Proportioning Direct Radiation, by James A. Donnelly (AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS TRANSACTIONS, Vol. 21, p. 535), gives the proportionate heat losses from buildings, the proportionate transmission from direct radiators, and the proportionate radiation required (with steam at 215 deg. fahr.) for various room temperatures when the outside temperature is 0 deg.

TABLE 6. EFFECT OF ROOM TEMPERATURE ON HEAT LOSS AND SIZE OF RADIATOR

Room Temperature Deg. Fahr.	Proportionate Loss in B.t.u.	Difference in Temperature Between Radiator and Room	Proportionate Transmission in B.t.u.	*Room* Temperature Deg. Fahr.	Proportionate Surface Required Sq. Ft.
35	0.50	180	1.33	35	0.38
40	0.57	175	1.28	40	0.45
45	0.64	170	1.23	45	0.52
50	0.71	165	1.18	50	0.60
55	0.79	160	1.14	55	0.69
60	0.86	155	1.09	60	0.79
65	0.93	150	1.05	65	0.89
70*	1.00*	145*	1.00*	70*	1.00*
75	1.07	140	0.96	75	1.11
80	1.14	135	0.91	80	1.25
85	1.21	130	0.87	85	1.39
90	1.29	125	0.83	90	1.55
95	1.36	120	0.78	95	1.74
100	1.43	115	0.74	100	1.93
105	1.50	110	0.70	105	2.14
110	1.57	105	0.66	110	2.38
115	1.64	100	0.62	115	2.65
120	1.71	95	0.58	120	2.95

* Standard Conditions.

Assuming that the rate of heat loss from a building varies directly with the difference between the outside temperature and the building temperature, and considering the heat loss for zero outside, 70 deg. inside as the standard, or 100 per cent; the second column shows the proportionate loss of heat from a building when the outside temperature is zero, and the inside temperature is as given in the first column.

Assuming that the rate of transmission from a direct radiator to the air of a building is in proportion to their difference in temperature, with a variation in the rate of transmission of 2 per cent, greater or less, for each 10 deg. increase or decrease in their temperature difference, and considering 145 deg. difference in temperature (steam 215 deg., building 70 deg.) as standard, or 100 per cent transmission, the fourth column shows the proportionate transmission when the difference in temperature is as given in the third column.

Assuming that under standard conditions of outside temperature zero, building temperature 70 deg., and radiator temperature 215 deg. (or 145 deg. difference between the radiator and room) the amount of radiation necessary is 100 per cent, the proportionate amounts of radiation given in the sixth column are those necessary to heat a building to the temperatures given in the fifth column, when the outside temperature is zero.

Note.—The amount of surface required for heating is always obtained by dividing the heat loss from the building by the amount of heat transmitted per square foot of radiation. Therefore, as may be seen from the above tables, the proportionate amount of surface required for heating is obtained by dividing the proportionate heat loss from the building by the proportionate transmission of the radiator, in each case.

Table 6 may be used to find the proportionate amount of radiation necessary to heat a room to any desired inside temperature, other than 70 deg. fahr., when the outside minimum temperature is other than zero, and with a radiator temperature other than standard. Find the difference between the outside temperature and the room temperature in

the *first column;* divide the proportionate heat loss opposite this amount, in the *second column*, by the proportionate transmission opposite the difference in temperature between the radiator and the room, as given in the *fourth column*, and the result will be the proportionate amount of radiation required.

Example.—What is the proportionate amount of radiation required to heat a room to 90 deg. fahr. with a temperature of −20 deg. fahr. outside and a steam temperature of 240 deg. fahr.?

Solution.—The difference in temperature between −20 deg. fahr. outside, and 90 deg. fahr. inside, is 110 deg. fahr. Opposite 110, the proportionate heat loss, or 1.57, is found in the second column. The difference in temperature between the radiator and the room (steam 240 deg. fahr., room 90 deg. fahr.) is 150 deg. fahr. Opposite this, the proportionate transmission 1.05 is found in the fourth column. Divide 1.57 by 1.05 and the quotient, 1.50, is the proportionate amount of radiation required.

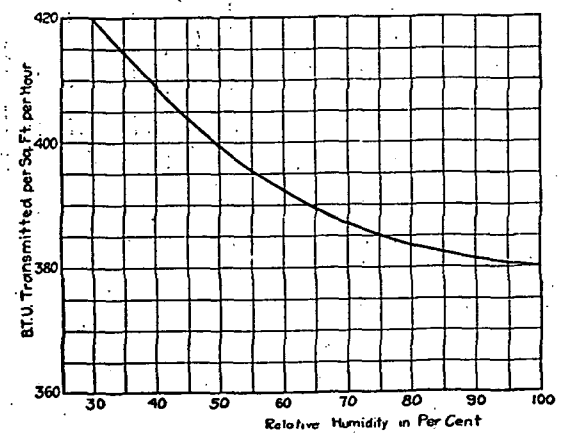


FIG. 1. EFFECT OF HUMIDITY ON HEAT TRANSMISSION

EFFECT OF HUMIDITY

The late John R. Allen, while Director of the Society's Research Laboratory, submitted a paper as a report (A. S. H. V. E. TRANSACTIONS, Vol. 26, p. 11), which in addition to the treatise on the heat emitted by various types of radiation, from which the preceding tables were calculated gives other data from which the following is taken.

Fig. 1 shows the effect of increasing the humidity upon the heat transmission. It will be noted that with extreme change of humidity there is a slight change in the heat transmission, the heat transmission reducing slightly as the humidity increases. Humidity can have very little, if any effect upon radiation, and the effect of humidity must therefore change the convected heat lost by the radiator. This change of convected heat is probably due to the change in the density of the air passing over the radiator.

WARMING THE RADIATOR

It is often very important to know the maximum condensation that occurs in a radiator when steam is turned on. Fig. 2 shows the condensation rate in pounds per hour for the time elapsing after steam is turned into the radiator. It will be noticed that the maximum condensation in the radiator occurs 10 min. after steam is turned on,

and in that case it amounts to about three and one-half times normal condensation. After the end of 25 min., the radiator reached a normal rate of condensation. This curve was made from observations at intervals of 10 min. so that the intermediate points between the 10 min. points are not known, and the form of the curve is not exact. It shows, however, that when a plant is initially started up and the system filled with steam during a short period of time the demand made upon the boiler may be very much higher than the normal demand. In practice the rate of steam supply to the radiator while heating-up is however, generally retarded by controlled elimination of air through air valves or traps and if sufficient time is allowed for the heating-up process, overload on the boiler may be practically eliminated.

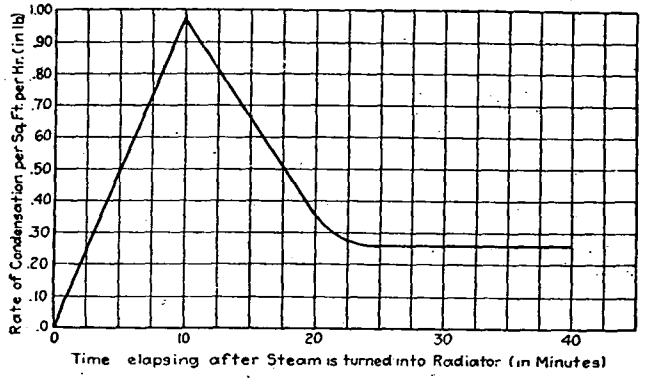


FIG. 2. CHART SHOWS THE STEAM DEMAND RATE FOR HEATING-UP A CAST IRON RADIATOR WITH FREE AIR VENTING AND AMPLE STEAM SUPPLY

EFFECT OF PAINTING CAST IRON RADIATORS

The effect of painting is to change the radiation constant of the radiating surface and has practically no effect upon the heat lost by convection. It is, therefore, a surface effect and it makes no difference what paints are placed on the radiator as a priming coat, the results are always dependent upon the last coat of paint put upon the radiator. In radiators having a large proportion of radiating surface such as pipe coils or wall coils, the effect of painting will be more marked than in four-column radiators having a comparatively small radiating surface in proportion to convecting surface. All finely ground materials have about the same radiation constant. Therefore all paints having finely ground pigments will give about the same effect. Metals have a poor radiating effect so that any paint involving flake metal, such as the bronze, will have a low radiating constant.

The effects of painting a six-section 32-in. three-column radiator as found by Wm. H. Severns are given in Table 7.

TABLE 7. EFFECT OF PAINTING 32-IN. THREE-COLUMN, 6-SECTION CAST IRON RADIATORS*

RADIATOR NO.	FINISH	AREA SQ. FT.	COEFFICIENT OF HEAT TRANS. B.T.U.	RELATIVE HEATING VALUE PER CENT
1	Bare iron, foundry finish	27	1.77	100.5
2	One coat of aluminum bronze	27	1.60	90.8
3	Gray paint dipped	27	1.78	101.1
4	One coat dull black Pecora paint	27	1.76	100.0

*Comparative tests of Radiator Finishes by Wm. H. Severns, JOURNAL, AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS, January, 1927.

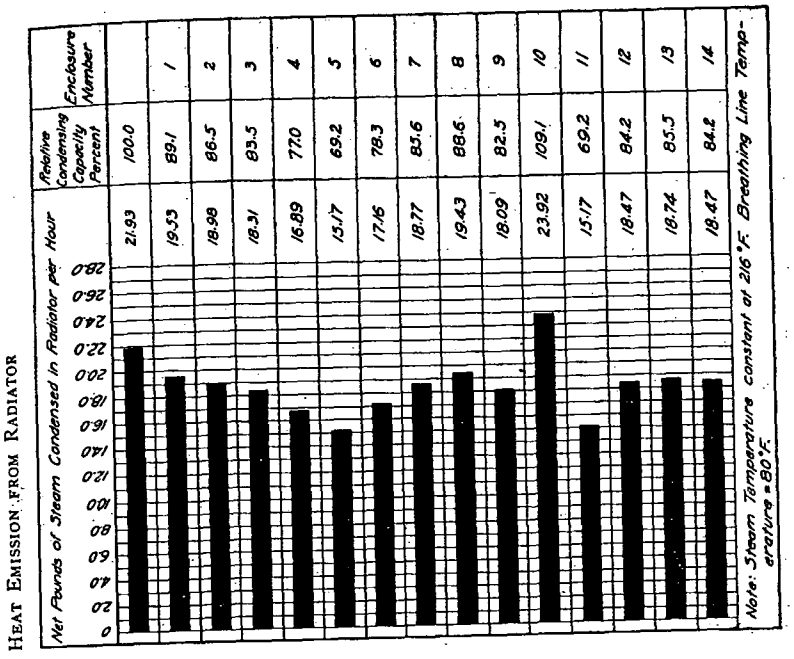


TABLE 8. EFFECT OF ENCLOSURE ON HEAT EMISSION FROM RADIATOR

Enclosure Number	Description of Enclosure: Height of Top of Enclosure Above Top of Radiator	Inlet	Outlet	Free Area of Inlet Sq. In.	Free Area of Outlet Sq. In.
	Radiator not enclosed—Painted (not dipped) with two coats of black Pecora paint				
1	0.0"	4"×50" Across front	9¼"×50" Open top	200.0	462.5
2	0.0"	4"×50" Across front	9¼"×50" Grilled top	200.0	209.4
3	0.0"	4"×50" Across front	12½"×50" Open front	200.0	625.0
4	0.0"	4"×50" Across front	4"×50" Open front	200.0	200.0
5	0.0"	4"×50" Across front	4"×50" Grilled front	200.0	92.1
6	17½"	4"×50" Across front	4"×50" Grilled front	200.0	92.1
7	34"	4"×50" Across front	4"×50" Grilled front	200.0	92.1
8	0.0"	4"×82½" Across front and ends	9¼"×50" Grilled top	330.0	209.4
9	0.0"	2-82½" Across front and ends	9¼"×50" Grilled top	165.0	209.4
10	34"	4"×82½" Across front and ends	9¼"×50" Open top	330.0	462.5
11	0.0"	4"×82½" Across front and ends	4"×50" Grilled front	330.0	92.1
12	0.0"	Punched metal grille front and ends, solid top. Grillework beginning 4" above floor. F.A. of grille = 44%			
13	0.0"	Woven metal grille front and ends, solid top. Grillework beginning 4" above floor. F.A. of grille = 53%			
14	0.0"	Same as (13) with F.A. of Grille = 42%			

Note: 20 Section, 38"3 Column, (Direct) C.I. Water Type Radiator used in all tests.

EFFECT OF ENCLOSURES, WITH CAST IRON RADIATORS

It is generally assumed that an enclosed radiator shows a decreased heat emission. This is borne out by results recently published by Kratz and Fahnestock, Table 8[a]. This data indicates that the heat emission from the enclosed radiator equals or exceeds that of an exposed radiator only in the case where the enclosure is much higher than the radiator so as to produce a pronounced chimney effect.

To accomplish best results, care must be exercised to follow certain rules in designing the enclosure, the most important of which are:

1. Enclosures should be insulated with 1 in. magnesia or asbestos block, lined with bright tin or non-corrosive sheet metal, placed next to the radiator.

2. The surface of the radiator should be painted flat black, maroon japan, white enamel or white zinc. If the radiator is entirely concealed it may be unpainted.

3. The free area of the grill or opening at the outlet should be not less than the free area through the sections of the radiator.

4. The free area of the grill or opening at the inlet should be not less than 80 per cent of the free area at the outlet.

5. If the outlet is in the face of the enclosure so that the air flow is horizontal, the free area of the outlet should be at least 150 per cent of the free area about the radiator, and the clear height between the top of the radiator and the underside of the top of the enclosure should be not less than the depth of the enclosure.

6. Best results are obtained with a tight fitting enclosure, provided the free area about the radiator at point of greatest restriction is not excessive. As a general rule the efficiency of the radiator is inversely proportional to the depth of the enclosure.

SPECIFICATION CLAUSES FOR CAST IRON RADIATORS

Specifications for radiation should contain the following clauses:

1. Manufacturers must guarantee that the heat emission per radiator shall not fall below the values given in their published literature.

2. Radiation must be free from flaws on surface and leaks at nipple connections, and guaranteed to stand a hydrostatic test of not less than 100 lb. per square inch.

3. Radiation must be thoroughly cleaned of all core sand, and if for vapor or modulation steam systems must be washed out and the openings plugged before shipment.

4. Radiation must not be placed where dirt can get into the interior and if to be placed in the weather or damp location must be given a priming coat of paint before shipment or immediately upon delivery at location.

5. Long or low radiators should be crated, and the crating not removed until placed in final location.

6. Radiators supported from the wall or ceiling shall be supported on steel or wrought-iron hangers.

[a]Effect of Enclosures on Radiator Performance by A. P. Kratz and M. K. Fahnestock, JOURNAL, AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS, June, 1927.

CHAPTER III

STEAM HEATING SYSTEMS AND PIPING

Description of Systems; Influence of Length of Run, Pressure Drop, Critical Velocities and Heating-up Periods; Pipe Size Tables for One-Pipe, Two-Pipe, Vapor and Vacuum Systems, Details of Piping Connections.

INTRODUCTION

ONE of the serious design problems facing every heating engineer and contractor is the selection of proper pipe sizes for steam heating systems. Until recently no uniformity of practice existed, and of the numerous tables available to the profession many indefinite and variable factors entered into the calculations with the result that a concerted effort was made by committees of the AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS and the *Heating and Piping Contractors' National Association* to study the subject of pipe sizes and compile tables with a scientific basis.

For several years the AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS' Research Laboratory has been investigating the flow of steam in pipes and the capacity of pipes for steam heating systems with the result that the reports of its Technical Advisory Committee on Pipe Sizes have been used by the AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS' Guide Committee and the *Heating and Piping Contractors' National Association* Committee on Standardization in the compilation of Standard Tables for Pipe Sizes of Steam Heating Systems.

The information acquired through the cooperative effort of these two organizations provides engineers and contractors with a standard method of selecting pipe sizes for steam heating systems, thus facilitating the designing of plants that are scientifically correct. All data in this chapter are so arranged that the subject is covered under four general divisions: (1) a brief description of systems, (2) a discussion of steam distribution, (3) pipe size tables for steam heating systems and (4) examples to show correct use of tables.

Where data have not been available from research work, standard formulae have been applied so that the user of these tables may feel confident that the values given may be applied with safety.

Wherever the words radiator or radiation are used throughout this chapter, they are intended to refer not only to the older types of radiation, but also to the newer types of radiators, heaters, concealed or cabinet styles.

Wherever the words equivalent radiation are used they are intended to

Material for this section of THE GUIDE especially prepared by the following committee: R. S. Franklin, *chairman;* C. V. Haynes, F. C. Houghten, E. N. Sanbern and F. W. Wandless.

refer to the equivalent capacity, of any of these types of heat-emitting units, in terms of the standard capacity of cast-iron radiation.

DESCRIPTION OF SYSTEMS

Piping systems for steam heating are broadly classified as gravity one-pipe, two-pipe, vapor and vacuum systems; the condensation returning to boiler by gravity or mechanical devices.

A few of the terms used in describing these systems are defined as follows:

A gravity system is one in which the water of condensation is returned to the source by the action of gravity.

A vacuum system is one which operates in whole or in part at pressures below atmospheric.

A vapor system is one which operates at low pressures and which employs devices for the limitation of pressure and for the control of the steam supply.

A down-feed or overhead system is one in which the supply main is above the level of the heating unit.

Up-feed systems are those in which the supply main is below the level of the heating units.

Supply mains are the pipes that convey the steam from its source to the branch risers of the heating units.

Branch risers are the pipes that convey the steam from the mains to the heating units or the condensate from the heating unit to the return main.

Return mains are the pipes that carry the condensate from the branch returns back to its destination. There are two kinds of returns, the *dry* and *wet*. The former is above the level of the water line of the boiler or its corresponding hydrostatic head and handles both air and water. It connects to a receiver where the air and water are separated. The *wet* return is below the level of the water line of the boiler or its hydrostatic head and handles only water.

The choice of gravity one-pipe, two-pipe, vapor or vacuum systems depends upon the requirements as to first cost, convenience, quality of service and local conditions. Theoretically, gravity one and two-pipe and vapor and vacuum systems are substantially on a par as to heating efficiency; that is to say, the major portion of the heat delivered is, or should be, dissipated by the heating unit.

It is essential that any system circulate steam uniformly throughout the entire installation, as too often certain defective features of a system will require that heat be kept on longer or to a greater degree than would otherwise be required to uniformly and satisfactorily heat the building. This will result in waste and overheating. The one important thing to be remembered in connection with all systems is that they shall circulate steam freely and uniformly to the heating units and remove and return condensation noiselessly.

One-Pipe Gravity Steam System.—The one-pipe system is generally the least expensive to install. It requires one combined supply and return

connection at the bottom of each heating unit to allow the condensation to flow back to the boiler in opposition to the incoming steam. There are many modifications of this system. The main should pitch down from the boiler in the direction of the flow of steam. The end of the main and some of the branch risers, if the run is long, should be dripped into the return line. If the return line is below the water line of the boiler they may be directly connected but should the return be above the water line of the boiler in this part of the system the main and branch risers should be dripped through water legs of sufficient length so that the steam pressure will not lift the water and blow steam through to the return main.

Air valves must be used on all heating units, also near the ends of mains

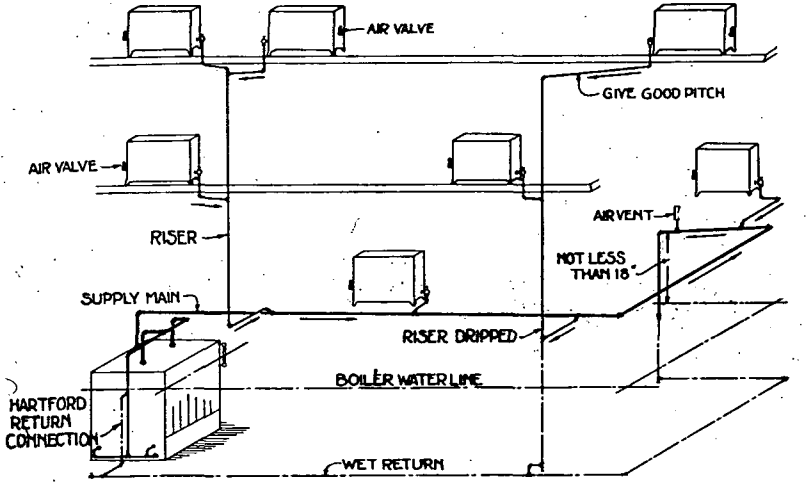


FIG. 1. TYPICAL GRAVITY ONE PIPE STEAM SYSTEM

before dropping below the water line. These valves may vent the air directly to the room or may be of a type that is connected to an air line pump which removes the air only and does not handle the condensation from the heating unit. Fractional control by means of valves on the heating units is not possible with one-pipe systems. During operation the heating unit supply valve must be either entirely open or entirely closed. This is necessary to prevent the retention of water and the noise due to intermittent inflow of steam and outflow of water that occurs when the valve is partly open.

This system is adaptable to automatic temperature control and is entirely satisfactory when properly designed, installed and operated.

Gravity one-pipe systems operating under slight pressures sometimes called vapor or vapor vacuum type are the same in design as to pipe sizes as the gravity one-pipe system, the only point of difference being the venting valves on the heating units and return main. These valves vent air from the system but prevent its return.

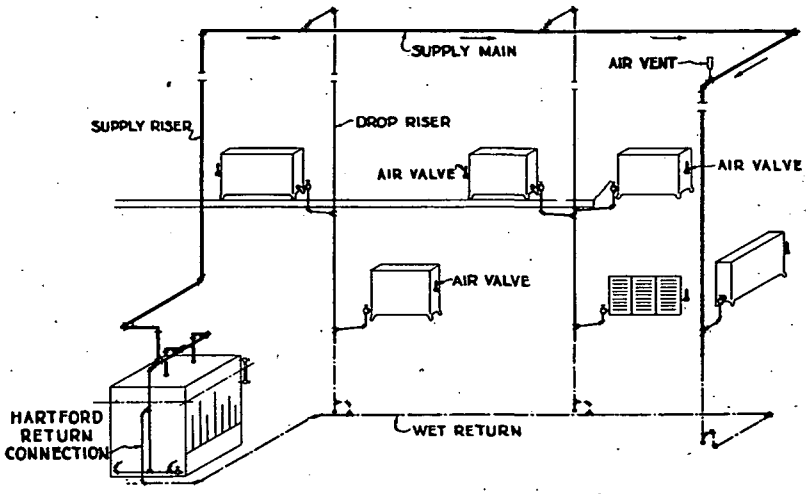


Fig. 2. Typical Gravity Downfeed Steam System

Two-pipe Gravity Systems.—Two-pipe systems require separate supply and return pipes and a supply and return connection for each heating unit for steam and condensation. Like one-pipe systems, they require air valves on heating units and mains. The inlet supply connections may be either at the top or the bottom of the unit, but the outlet is always at the bottom so that all condensation will drain through this to the return

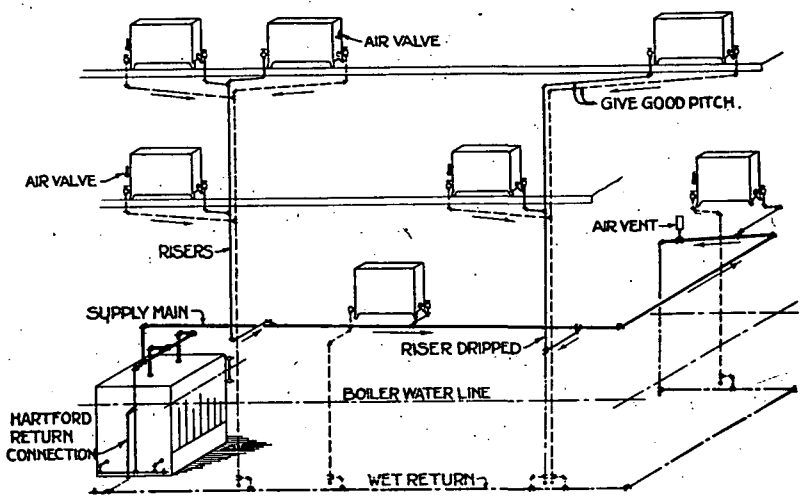


Fig. 3. Typical Gravity Two Pipe Steam System

mains, instead of back through the inlet connection to the supply mains, as with the one-pipe system. Both radiator connections should be valved.

The returns from heating units on several floors are usually connected into common risers and the various risers tie into the return system.

This return system, if kept above the water line so as to remain dry, is usually filled with steam (plus the water of condensation), at a pressure somewhere between that of the supply and that of the atmosphere, depending upon the amount of steam passing through the heating unit returns. This makes the gravity two-pipe system susceptible to the backing up of steam from one heating unit to another if return valve is left open, causing troubles due to water hammer, noise caused by counterflow and mixing of steam from the return with the condensation leaving the heating units and air binding due to the premature closing of air valves by

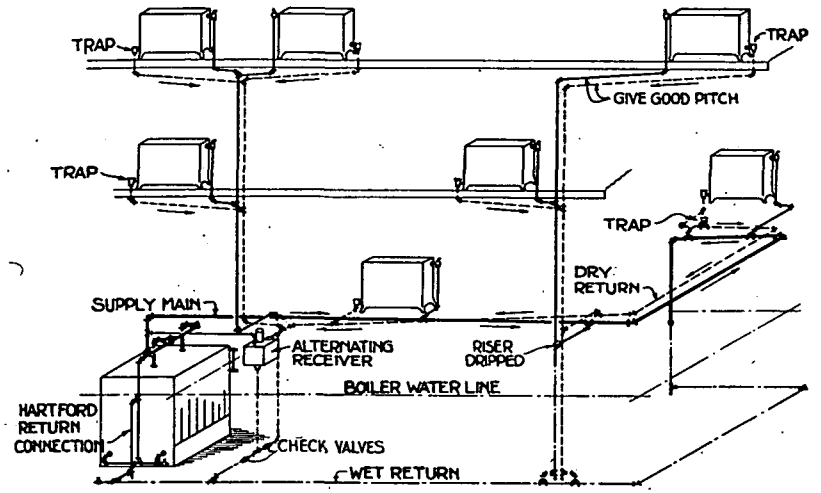


Fig. 4. Typical Gravity Vapor System With Receiver

steam entering at the return end of the heating units. Sometimes check valves are used on the return end of heating units to prevent steam backing into those which have been shut off. This practice is not desirable as condensation may collect in the heating units, endangering the boiler. The troubles from the backing up of steam in the returns are generally eliminated when all heating unit returns are connected separately into the wet return. The return mains are kept below the water line, so as to be wet.

The use of vacuum air valves and automatic temperature control on two-pipe systems with wet returns is not recommended.

Vapor Systems.—Generally vapor systems are specially designed two-pipe systems, operated at a very low pressure. They differ from the gravity two-pipe systems in four important particulars: (1) that the steam is prevented from entering and building up pressure in the return

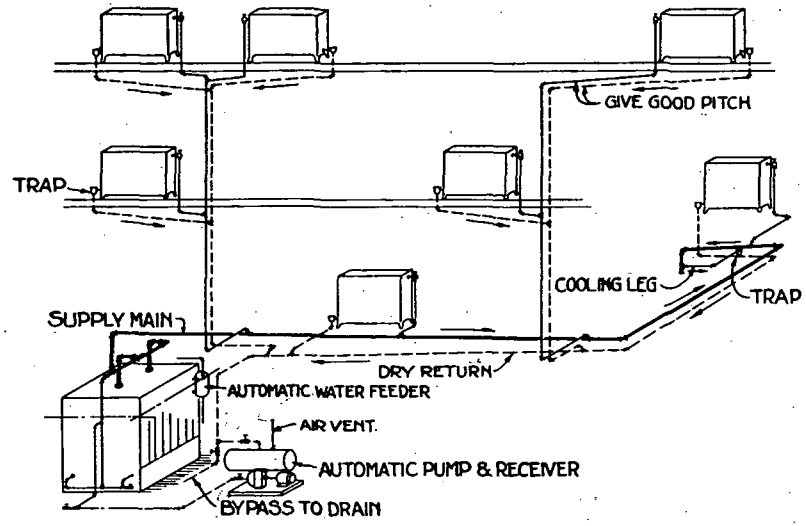


FIG. 5. TYPICAL INSTALLATION USING CONDENSATION PUMP

system by means of thermostatic or other forms of traps on the return ends of all heating units, (2) that the air is eliminated with the condensation through the heating unit returns into the return system and thence to the atmosphere through automatic vent valves or other forms of auto-

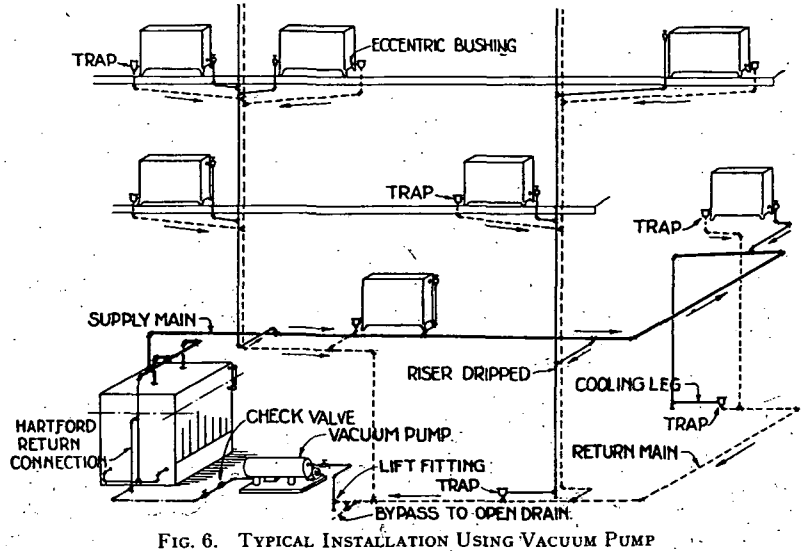


FIG. 6. TYPICAL INSTALLATION USING VACUUM PUMP

matic air venting apparatus, instead of through individual air valves on the radiators in the rooms, (3) that the backing up of water in returns may be prevented by the carrying of exceedingly low supply pressures, (4) that real fractional control is possible.

In vapor systems boiler protection is given by devices supplementing the damper regulator and may be in the form of an alternating receiver, return trap, equalizing or differential device. An approved return connection (Fig. 7) is quite extensively used in place of a check valve for partially preventing water from leaving the boiler.

Vapor systems are often provided with venting valves which prevent air from returning through the vent port or return traps thus permitting the formation of a partial vacuum when generation of steam pressure above atmospheric ceases. Such installations are termed vapor-vacuum systems.

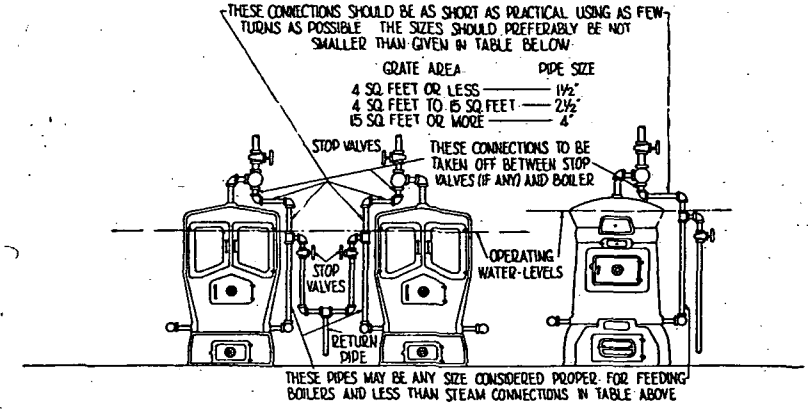


FIG. 7. CONNECTING TWO BOILERS USING THE APPROVED RETURN CONNECTION

Vacuum Pump Systems.—These are similar to vapor systems in every way, except that a pump is used to produce a vacuum on the return system for removing air and water. They permit wider variation in pressure differences between steam and return mains.

They are installed in buildings where it is required to operate at low initial pressures or where, by reason of the layout, radiators must be located below the water line of the boiler. These systems are also well adapted to large groups of widely separated buildings. They are common where exhaust steam is available, as they may be operated on a low back pressure, without appreciably decreasing the capacity or economy of steam engines. A vacuum pump is used to accelerate circulation by discharging both water and air, the water being returned to the boiler and the air vented to atmosphere.

Because of the greater pressure differential of vacuum systems the result of faulty grading of piping connections is less serious than in the other systems mentioned.

TABLE 1. FLOW OF STEAM IN PIPES

Flow of Steam in Pipes

P = Loss in Pressure in Lbs.
d = Inside Diameter of Pipe in Inches
L = Length of Pipe in Feet
D = Weight of 1 Cu Ft. of Steam
W = Lbs. of Steam per Min.

$$W = 87.0\sqrt{\frac{PDd^5}{\left(1+\frac{3.6}{d}\right)L}}$$

$$P = 0.000132\left(1+\frac{3.6}{d}\right)\frac{W^2L}{Dd^5}$$

Pressure Loss in Ozs.	Col. 1 $87.0\sqrt{\frac{P}{100}}$	Pipe Size Nominal	Actual Internal Diameter	Internal Area of Pipe Sq. Ins.	Col. 2 $\sqrt{\frac{d^5}{1+\frac{3.6}{d}}}$	Steam Press. by Gage	Col. 3 $\sqrt{D}$	Length of Pipe in Feet	Col. 4 $\sqrt{\frac{100}{L}}$
0.25	1.088	1	1.049	0.864	0.536	-1.0 *	0.187	20	2.240
0.50	1.538	1¼	1.380	1.496	1.178	-0.5 *	0.190	40	1.580
1.00	2.175	1½	1.610	2.036	1.828	0.0	0.193	60	1.290
2	3.076	2	2.067	3.356	3.710	0.3	0.195	80	1.120
3	3.767	2½	2.469	4.788	6.109	1.3	0.201	100	1.000
4	4.350	3	3.068	7.393	11.183	2.3	0.207	120	0.912
5	4.863	3½	3.548	9.887	16.705	5.3	0.223	140	0.841
6	5.328	4	4.026	12.730	23.631	10.3	0.245	160	0.793
7	5.755	4½	4.506	15.947	32.134	15.3	0.270	180	0.741
8	6.152	5	5.047	20.006	43.719	20.3	0.290	200	0.710
10	6.878	6	6.065	28.888	71.762	30.3	0.326	250	0.632
12	7.534	7	7.023	38.743	106.276	40.3	0.358	300	0.578
14	8.138	8	7.981	50.027	149.382	50.3	0.388	350	0.538
16	8.700	9	8.941	62.706	201.833	60.3	0.415	400	0.500
20	9.727	10	10.020	78.854	272.592	75.3	0.452	450	0.477
24	10.655	12	12.000	113.098	437.503	100.3	0.507	500	0.447
28	11.509	14	13.250	137.880	566.693	125.3	0.557	600	0.407
32	12.304	16	15.250	182.655	816.872	150.3	0.603	700	0.378
40	13.756	Column 1 × 2 × 3 × 4 = lb. of steam per minute that will flow through a straight pipe for a given condition.				175.3	0.645	800	0.354
48	15.069					200.3	0.685	900	0.333
80	19.454	*Example.*—1 oz. drop — 2 in. pipe — 1.3 lb. press. — 100 ft. equivalent length:						1000	0.316
160	27.512	2.175 × 3.710 × 0.201 × 1 = 1.6219 lb. per min. 1.6219 × 60 × 4 = 389.3 sq. ft. equivalent radiation.						1200	0.289
320	38.908	Table 1 does not allow for entrained water in low-pressure steam, condensation in covered pipe and roughness in commercial pipe as found in practice.						1500	0.258
480	47.652							2000	0.224

lb. per sq. in. gage = 2.04 in. Vacuum, Mercury Column.

STEAM DISTRIBUTION

The piping for steam distribution will be divided into two classes: (1) transmission mains, (2) service piping.

Transmission mains are defined as those that convey steam for a considerable distance either through or between buildings such as in district heating plants. In this type the steam is usually generated and transmitted to the building under high pressure where by means of a pressure reducing valve it is lowered to the pressure required in the building. The velocities of flow used in the transmission mains are limited by the available or allowable drop in pressure. See Table 2 for capacity of pipes at various pressures.

Service piping is defined as that which conveys the steam and condensate in the building, starting either at the boiler or other source of supply and comprising of the mains, branches, risers, radiator connections and return piping. This part of the system is usually low pressure and the pipe sizes are larger, as the velocity of the steam is lower and the available or allowable drop in pressure is small. See Tables 10 to 18 for the service pipe sizes for various systems.

STEAM HEATING PIPE SIZES

Generally, in using tables for steam heating pipe sizes, it is difficult to determine the length of run upon which they are based. Usually some allowance is made for one or more such items as: condensation in the pipe, equivalent length of pipe, for fittings, valves, etc., but it is generally difficult to determine what factors have been allowed for, and what percentage of allowance has been made. In compiling the Tables 1–18 and other data for THE GUIDE, 1929, every attempt has been made to eliminate such indefinite and conflicting factors.

The principal factors upon which the determination of pipe sizes for steam heating depends, are:

1. The equivalent length of the run from the boiler, or source of steam supply, to the farthest heating unit.
2. The total pressure drop, which may be allowed, between the source of supply and the end of the return system.
3. The maximum velocity of steam allowable for quiet and dependable operation of the system.
4. Unusual conditions in the building to be heated.

Length of Run

The length of run must not only include the actual linear feet of straight pipe, but also the proper allowance for fittings, valves and other items which cause drop in pressure. (See Table 4.)

Pressure Drop

Theoretically there are several factors to be considered such as initial pressure and the pressure required at the end of the line, but it is most important that (1) the total pressure drop does not exceed the initial pressure of the system, (2) that the pressure drop is not so great as to

cause high velocities and in the case of counter flowing condensate cause water hammer, (3) that there is a constant initial pressure.

It is recommended that all systems be designed for low initial pressure and a reasonably small pressure drop. Such systems will operate under higher pressures without difficulty. When a system is designed for high pressure with a relatively large pressure drop and then operated at a low pressure, it is apt to be noisy and have poor circulation.

It is recommended that the total pressure drop never exceed one-half of the initial pressure. This applies to cases where the condensate is flowing in the same direction as the steam but in the case of counter flowing condensate the velocities should not exceed those shown in Tables 5, 6 and 7.

Maximum Velocity

The capacity of pipe of a given size in any part of a steam or vapor heating system depends upon the quantity of condensation present, as well as the available pressure drop in the pipe. Where no water is present or where a limited quantity flows by gravity in the same direction as the steam the available pressure drop only need be considered.

Where water and steam flow counter to each other the velocity of the steam must not exceed certain values above which disturbance between the counter-flowing steam and water may produce objectionable sounds, water hammer, or retain water in some parts of the system until pressure goes off. The velocity at which such disturbance takes place depends upon the size of the pipe, its position (whether, vertical or horizontal), its pitch and the quantity of water flowing counter to the steam.

Unusual Conditions

Under this heading are the character and class of the building, the periodicity of use and the degree of normal temperature and the time in which it is to be attained at the beginning of each period.

In public buildings, schools, offices, stores and such buildings (where the occupants are normally at rest) the building should be heated to or near its required temperature at all times. In places of assemblage such as churches, theatres and auditoriums little heat should be used, for as the occupants fill the building it becomes a case of ventilation instead of heating. In factories or other buildings the heat given off by machinery, occupants and illumination and that absorbed by the contents of the building should be taken into account. In buildings that are intermittently heated the extra load due to heating up of a cold system within a stated time must be considered in determining the pipe sizes.

GENERAL DATA ON PIPE SIZE TABLES

The following Tables 1 to 18 have been compiled for use in designing the usual types of steam heating systems, and may be used, by those experienced in the profession, with satisfactory results. The following general principles should be followed:

1. It is recommended that the initial pressure be kept as low as possible, not exceeding 5 lb. gage.

2. It is recommended that the drop in pressure in the mains and riser to the farthest heating unit should not exceed 1 oz. per 100 ft. of straight pipe or its equivalent length, with a lower rate of drop for systems with long runs.[1]

3. In small installations, such as residences, where the longest actual run is seldom over 200 ft. and where the firing periods extend over several hours, resulting in boiler pressure, fluctuating from zero to about 1 lb., the total pressure drop should not exceed 2 oz. for gravity systems. In large buildings, where boilers are under the constant care of a fireman and a uniform pressure is maintained, and where the water line difference will permit, the total drop in pressure may range from 3 to 8 oz. depending upon the equivalent length of the longest run.

4. The total allowable drop in pressure depends upon (*a*) the water line difference, (*b*) the equivalent length of main and riser from the boiler to the farthest heating unit, and (*c*) the regularity of the pressure maintained at the boiler or source of steam supply.

5. The water line difference or distance between the water line of the boiler and the low point of steam main and dry return main should be not less than 24 in., because of the heavy drop in pressure from condensation in heating up a cold system. This difference should be increased 2 in. for every ounce pressure drop in the system. If the total pressure drop were 6 oz., the water line difference should be $6 \times 2 + 24$ or 36 in.

6. There should be a nearly uniform drop in pressure between the source of steam supply and the farthest heating unit on every riser. Care should be taken however, to see that the maximum allowable velocity for smooth operation is not exceeded.

7. In using this method of proportioning a system, care must be exercised to see that no pipe carrying condensate counter to the steam, is loaded to a capacity above the maximum for the particular part of a system in question as shown in Tables 5, 6 and 10 to 18.

DESCRIPTION OF TABLES

Tables 1 to 9 have been compiled for the use of the engineer who wishes to design a system with a pressure drop other than those shown in Tables 11 to 16. These tables may also be used to design transmission mains.

Table 1 gives the numerical value of the four factors of the Babcock formula for various sizes and lengths of pipe and various initial pressures and pressure drops. By multiplying together the four factors for any set of conditions the pound of steam per minute which will flow through the pipe may be found, as illustrated at the bottom of the table.

Table 2 is a basic table giving the theoretical capacities of pipe in square feet of direct cast-iron radiation (Based on ¼ lb. steam per hour per square foot) and the resulting velocity in feet per second for various pressure drops in ounces per 100 ft. length of pipe or equivalent length and with an initial steam pressure of 1 lb. gage. This table was compiled from the values given in Table 1. In using Table 1 or 2 the total pressure drop figured should never equal or exceed the initial pressure. It is recommended that the total pressure drop be less than one-half the initial pressure.

Table 3 is to be used with Table 2 for calculating the capacity of a steam pipe, for other initial pressures and lengths when the capacity is known for 1 lb. pressure and 100 ft. length. See examples for Table 3.

Table 4 gives the length of pipe in feet to be added to the actual length of run to obtain the equivalent length.

Table 5 gives the capacities of up-feed *one*-pipe risers based upon the

[1]This rule applies only when the amount of radiation on any riser does not exceed the values in Tables 5, 6 and 7.

Table 2. Pressure Loss, Capacity in Square Feet of Equivalent Radiation and Velocity Relationship Based on Table 1, for Various Pressure Drops with 1 Lb. Initial Steam Pressure

(Note.—No allowance for condensation in pipe—unusual friction—scale—corrosion or other factors.)

Pressure Loss in Ounces per 100 Ft.	Pipe Size 1"		1¼"		1½"		2"		2½"		3"		3½"	
	Sq. Ft.	Velocity Ft. per Second	Sq. Ft.	Velocity Ft. per Second	Sq. Ft.	Velocity Ft. per Second	Sq. Ft.	Velocity Ft. per Second	Sq. Ft.	Velocity Ft. per Second	Sq. Ft.	Velocity Ft. per Second	Sq. Ft.	Velocity Ft. per Second
¼	28	7.5	61	9	95	11	193	14	318	17	581	21	869	23
½	39	12	87	15	134	17	273	21	449	24	822	30	1228	33
1	56	17	122	21	190	24	386	31	635	36	1163	42	1737	47
2	79	25	173	30	269	34	546	43	898	50	1645	60	2457	68
3	96	28	212	38	329	42	668	53	1100	62	2014	74	3009	84
4	111	35	245	43	380	49	771	62	1270	72	2326	85	3474	97
5	124	37	274	47	425	55	863	69	1421	80	2600	95	3884	109
6	136	40	300	52	466	59	945	77	1556	88	2848	105	4255	118
7	147	43	324	56	503	66	1020	83	1681	95	3077	113	4596	128
8	157	47	346	61	538	70	1091	89	1797	102	3289	122	4913	136
10	176	52	387	68	601	79	1220	99	2009	114	3677	135	5493	151
12	192	58	424	74	659	87	1336	109	2201	125	4028	148	6017	167
14	208	63	458	80	711	94	1443	118	2377	134	4351	164	6500	180
16	223	70	490	86	760	100	1543	126	2541	144	4651	175	6948	192
20	249	75	548	96	850	112	1806	148	2841	161	5200	196	7768	215
24	273	82	600	106	931	124	1890	154	3113	177	5697	215	8510	238

Table 2. (Continued)

Pressure Loss in Ounces per 100 Ft.	Pipe Size 4"		5"		6"		8"		10"		12"		16"	
	Sq. Ft.	Velocity Ft. per Second	Sq. Ft.	Velocity Ft. per Second	Sq. Ft.	Velocity Ft. per Second	Sq. Ft.	Velocity Ft. per Second	Sq. Ft.	Velocity Ft. per Second	Sq. Ft.	Velocity Ft. per Second	Sq. Ft.	Velocity Ft. per Second
¼	1229	26	2273	29	3731	35	7766	42	14,172	48	22,746	52	42,470	62
½	1738	37	3214	41	5276	49	10,983	60	20,043	72	32,168	76	60,061	88
1	2457	52	4546	49	7462	70	15,533	86	28,345	100	45,492	108	84,940	125
2	3475	74	6429	84	10,553	94	21,967	112	40,085	140	64,336	152	121,012	180
3	4256	91	7874	104	12,924	121	26,904	144	49,094	172	78,795	184	147,120	220
4	4914	105	9092	121	14,924	139	31,066	164	56,689	192	90,985	212	169,879	252
5	5494	118	10,165	135	16,685	156	34,733	184	63,380	224	101,724	240	189,937	280
6	6019	128	11,135	148	18,278	168	38,048	204	69,430	244	111,433	264	208,059	308
7	6501	139	12,027	160	19,742	174	41,096	220	74,993	264	120,361	288	224,729	336
8	6950	148	12,858	172	21,105	196	43,934	234	80,171	284	128,672	304	240,245	356
10	7770	166	14,376	193	23,597	216	49,120	268	89,633	312	143,860	340	268,603	400
12	8512	182	15,748	212	25,849	232	53,808	288	98,188	344	157,590	372	294,236	436
14	9194	196	17,009	224	27,920	260	58,120	316	106,056	372	170,217	404	317,815	474
16	9829	211	18,184	234	29,848	276	62,132	340	113,378	394	181,969	428	339,758	508
20	10,989	235	20,331	260	33,371	316	69,466	380	126,768	444	203,448	480	379,861	568
24	12,038	249	22,270	280	36,556	332	76,096	412	138,859	484	222,866	520	416,117	624

Note 1.—Capacities based on ¼ lb. condensation per square foot equivalent radiation—steam and condensation flowing in same direction—actual diameter of standard pipe.

Note 2.—For capacity of pipe with a given pressure drop, in a length other than 100 ft., multiply the capacity in this table for the given pressure per 100 ft. drop by the factor for required length, Column *B*, Table 3.

Note 3.—For capacity with initial pressures other than 1 lb., multiply capacity given in this table by factor for the required initial pressure. Column 2, Table 3.

Note 4.—To determine pressure loss with a given capacity for other lengths of pipe than 100 ft., multiply pressure loss given in this table for the given capacity by the required length of pipe and divide by 100.

Note 5.—Extra length to be added to straight run of pipe, for various fittings and valves to determine equivalent length. (See Table 4.)

Note 6.—All pipe should be well reamed and free from constrictions. (See Tables 7, 8 and 9.)

TABLE 3. CONSTANTS FOR VARIOUS LENGTHS AND INITIAL PRESSURES

STEAM PRESSURE GAGE LB.	CONSTANT BY WHICH TO MULTIPLY CAPACITY OF ANY PIPE FOR 1 LB. GAGE STEAM PRESSURE TO OBTAIN CAPACITY OF SAME PIPE FOR PRESSURE IN COL. 1	LENGTH OF PIPE FT.	CONSTANT BY WHICH TO MULTIPLY CAPACITY OF 100 FT. PIPE TO OBTAIN CAPACITY OF SAME SIZED PIPE WITH SAME PRESSURE, AND LENGTH AS GIVEN IN COL. *A*
Col. 1	Col. 2	Col. *A*	Col. *B*
0	0.92	20	2.240
1	1.00	40	1.580
2	1.03	60	1.290
5	1.11	80	1.120
10	1.24	100	1.000
15	1.35	120	0.912
20	1.45	140	0.841
30	1.63	160	0.793
40	1.79	180	0.741
50	1.94	200	0.710
60	2.08	250	0.632
75	2.26	300	0.578
100	2.54	350	0.538
125	2.79	400	0.500
150	3.02	450	0.477
175	3.23	500	0.447
200	3.44	600	0.407
...	....	700	0.378
...	....	800	0.354
...	....	900	0.333
...	....	1000	0.316
...	....	1400	0.267

TABLE 4. LENGTH IN FEET OF PIPE TO BE ADDED TO ACTUAL LENGTH OF RUN TO OBTAIN EQUIVALENT LENGTH

SIZE OF PIPE	ST'D. ELBOW	SIDE OUTLET TEE	GATE VALVE	GLOBE VALVE	ANGLE VALVE
	Length in Feet to be Added in Run				
2″	5	16	2	18	9
2½″	7	20	3	25	12
3″	10	26	3	33	16
3½″	12	31	4	39	19
4″	14	35	5	45	22
5″	18	44	7	57	28
6″	22	50	9	70	32
7″	26	55	10	82	37
8″	31	63	12	94	42
9″	35	69	13	105	47
10″	39	76	15	118	52
12″	47	90	18	140	63
14″	53	105	20	160	72

Example of length in feet of pipe to be added to actual length of run.



maximum allowable velocities as determined by the experiments of the Society's Research Laboratory. In designing a heating system no up-feed one-pipe riser should be figured to exceed the capacities indicated in this table.

Table 6 gives the maximum allowable capacity of up-feed *two*-pipe risers as determined by the experiments of the Society's Research Laboratory. In designing a heating system no up-feed two-pipe riser should be figured to exceed the capacities indicated in this table. This is based on the condensate of the riser returning against the flow of steam.

Table 7 gives the capacity of horizontal steam lines with various pitches. These values are for horizontal branches to the heating unit with the condensate of the steam line returning against the flow of steam. These values are safe for good pipe practice. It is not recommended that the pitch be less than ½ in. in 10 ft.

Table 8 gives the Society's Research Laboratory's finding on the decrease in the capacity of pipes not properly reamed.

Where the velocity of steam is the limiting factor in the capacity of a pipe, care must be taken that this velocity is not exceeded in any part of the pipe or fittings by a constriction, since the velocity at any one constriction will limit the whole system. For this reason, particular care must be taken to ream such pipe and guard against pipe thread compound constricting it at joints.

The pipe thread compound should be applied only to the male threads with a stiff brush.

Table 9 shows variation in capacity of a pipe as affected by variation of size and smoothness of pipe generally found on the market. The maximum and minimum results were obtained by picking out very smooth and very rough pipe from the stock room of a large manufacturer.

Tables 10, 11 and 12 have been compiled from tests run in the Society's Research Laboratory. They are figured on a 1 oz. pressure drop per 100 ft. equivalent length of run. There has been no attempt made to balance the system. This was not felt necessary due to the short runs of pipe and the small systems they would be used for. These tables are intended as a safe guide for the contractor or steam-fitter who often has these small jobs to install and who do not wish to have elaborate plans made.

Table 10 is a pipe sizing table for small one-pipe gravity low-pressure steam heating systems. This table was designed to meet the requirements of those laying out small systems where the equivalent length of run from the boiler or pressure reducing valve to the farthest heating unit is no greater than 200 ft. The capacities are based upon 1 oz. drop in pressure per 100 ft. equivalent length of run excepting where the maximum allowable velocity limits the capacity below this value. The capacities of supply mains as given in Column *B* are based upon a pressure drop of 1 oz. per 100 ft. equivalent length. The capacities of up-feed risers as given in Column *C* are based upon the maximum velocity. The capacities of branches to risers and heating units are based upon past experience and the Laboratory's findings.

Table 11 is for small two-pipe systems, and is similar to Table 10. It gives values for parts of a two-pipe system. It is based on a pressure drop

Table 5. Maximum Allowable Capacities of Up-Feed Risers for One-Pipe Low Pressure Steam

Based on A. S. H. V. E. Research Laboratory Tests

Pipe Size	Velocity Feet per Second	Pressure Drop Ounces per 100 Ft.	Capacity		
			Sq. Ft. Radiation	B.t.u. per Hour	Lb. Steam per Hour
A	*B*	*C*	*D*	*E*	*F*
1"	14.1	0.68	45	10,961	11.3
1¼"	17.6	0.66	98	23,765	24.5
1½"	20.0	0.66	152	36,860	38.0
2"	23.0	0.57	288	69,840	72.0
2½"	26.0	0.54	464	112,520	116.0
3"	29.0	0.48	799	193,600	199.8
3½"	31.0	0.44	1144	277,000	286.0
4"	32.0	0.39	1520	368,000	380.0

Note 1.—Above capacities should never be exceeded on one-pipe risers.

Note 2.—Capacities based on ¼ lb. condensation per square foot equivalent radiation and actual diameter of standard pipe.

Note 3.—All pipe should be well reamed and free from constrictions. Fittings should be up to size. (See Tables 8 and 9.)

Table 6. Maximum Allowable Capacities of Up-Feed Risers for Two-Pipe Low Pressure Steam

Based on A. S. H. V. E. Research Laboratory Tests

Pipe Size	Velocity Feet per Second	Pressure Drop Ounces per 100 Ft.	Capacity		
			Sq. Ft. Radiation	B.t.u. per Hour	Lb. Steam per Hour
A	*B*	*C*	*D*	*E*	*F*
¾"	20	.....	40	9550	10.0
1"	23	1.78	74	17,900	18.45
1¼"	27	1.57	151	36,500	37.65
1½"	30	1.48	228	55,200	57.0
2"	35	1.33	438	106,100	109.5
2½"	38	1.16	678	164,100	169.4
3"	41	0.95	1129	273,500	282.2
3½"	42	0.81	1548	375,500	387.0
4"	43	0.71	2042	495,000	510.5

Note 1.—Above capacities should never be exceeded on two-pipe risers.

Note 2.—Capacities based on ¼ lb. condensation per square foot equivalent radiation and actual diameter of standard pipe.

Note 3.—All pipe should be well reamed and free from constrictions. Fittings should be up to size. (See Tables 8 and 9.)

of 1 oz. per 100 ft. where the greatest equivalent length of run from the boiler to the farthest heating unit does not exceed 200 ft.

Table 12 is recommended for laying out small vapor systems on a basis of 1 oz. per 100 ft. where the greatest equivalent length of run from the boiler to the farthest heating unit does not exceed 200 ft.

Tables 13 to 18 were compiled from the test data of the Society's Research Laboratory and are for various types of balanced systems with different total pressure drops. These tables with their foot-notes may be used by any one with a knowledge of the profession to obtain satisfactory results. They cover the larger systems with total equivalent length of runs from 100 to 1200 ft.

Tables 13 and 14 were designed for larger one and two-pipe low-pressure gravity steam heating systems, respectively. These tables are based upon a 4 oz. pressure drop from the boiler to the farthest heating unit and give capacities based upon such pressure drop for equivalent lengths ranging from 100 to 600 ft. These tables can be used for determining the size of pipe necessary to handle a given amount of heating surface, either in a main, branch to the riser, riser, or heating unit branch. Risers, or branches to risers or heating units, must not, however, be loaded above

Table 7. Comparative Capacity of Steam Lines at Various Pitches*

Pitch of Pipe in Inches per 10 Ft.

Pitch of Pipe—¼ in.		½ in.		1 in.		1½ in.		2 in.		3 in.		4 in.		5 in.	
Pipe Size	Sq. Ft. Rad. Based on 240 B.t.u.	Max. Vel.	Sq. Ft. Rad. Based on 240 B.t.u.	Max. Vel.	Sq. Ft. Rad. Based on 240 B.t.u.	Max. Vel.	Sq. Ft. Rad. Based on 240 B.t.u.	Max. Vel.	Sq. Ft. Rad. Based on 240 B.t.u.	Max. Vel.	Sq. Ft. Rad. Based on 240 B.t.u.	Max. Vel.	Sq. Ft. Rad. Based on 240 B.t.u.	Max. Vel.	Sq. Ft. Rad. Based on 240 B.t.u.	Max. Vel.
¾"	25.0	12	30.3	14	37.3	18	40.4	19	42.5	20	46.1	21	47.5	22	49.3	23
1"	45.8	12	52.6	15	63.0	17	70.0	20	75.2	22	83.0	23	87.9	25	90.2	26
1¼"	104.9	18	117.2	20	133.0	23	144.5	25	154.0	27	165.0	28	172.6	29	178.2	31
1½"	142.6	18	159.0	21	181.0	23	196.5	25	209.3	27	224.0	28	234.8	30	242.6	31
2"	236.0	19	263.5	20	299.5	23	325.5	25	346.5	27	371.5	28	388.4	29	401.1	30

Table 8. Effect of Reaming Entrance to One-Pipe Risers*

	Maximum Capacity of Riser	Per Cent Decrease
Reamed entrances	24.7 lb. per hr.	0.0
Rounded entrances	23.9 lb. per hr.	3.2
Squared entrances	22.2 lb. per hr.	10.1
Three wheel cutter	19.2 lb. per hr.	22.2
Single wheel cutter	17.6 lb. per hr.	28.7

Table 9. Per Cent Difference in Capacity Due to Variation of Pipe Size and Smoothness*

	Maximum Condensation, Lb. per Hr.			
Capacity of Pipe	¾"	1"	1¼"	1½"
Minimum	14.00	24.89	45.42	70.50
Maximum	15.20	30.08	52.08	82.00
Per Cent Variation	8.6	20.8	14.7	16.3

*Data from American Society of Heating and Ventilating Engineers Research Laboratory.

the maximum capacities for different parts of the system as given in the tables.

Tables 15 and 16 are for sizing pipe for vapor systems where the equivalent length of run exceeds 200 ft. Table 15 is for systems up to 400 ft. equivalent length and is based upon a total pressure drop of 2 oz. from the source of steam supply to the farthest heating unit. Table 16 is for larger systems where the equivalent length of run from the boiler or source of steam supply does not exceed 600 ft. It is based upon a total pressure drop of 4 oz. Risers and branches to risers and heating units should not be loaded above their maximum capacity as given in Columns *F* and *G*.

Table 17 is a pipe sizing table for small vacuum pump systems where the equivalent length of run from the boiler or source of steam supply to the farthest heating unit ranges from 100 to 600 ft. The table is based

TABLE 10. PIPE SIZES FOR ONE-PIPE, GRAVITY, LOW PRESSURE STEAM HEATING SYSTEM, WHERE EQUIVALENT LENGTH OF RUN FROM BOILER OR SOURCE OF SUPPLY TO THE FARTHEST RADIATOR DOES NOT EXCEED 200 FT.

Capacity in Sq. Ft. of Equivalent Radiation

Based on Total Pressure Drop of 1 oz. per 100 ft.

Pipe Size Inches	Supply Main Dripped and Branches to Risers Dripped Steam and Condensate flowing in the same direction.	Supply Risers Up-Feed	Branches to Supply Risers and Radiators Not Dripped	Wet Return Main	Dry Return Main	Radiator Valve Sizes and Vertical Connections
A	*B*	*C*	*D**	*E*	*F*	*G*
¾	.....	25	.....	.....	.....	.....
1	56	45	20	700	320	20
1¼	122	98	55	1200	670	55
1½	190	152	81	1900	1058	81
2	386	288	165	4000	2300	165
2½	635	464	260	6700	3800	.....
3	1163	799	475	10,700	7000	.....
3½	1737	1144	745	.....	10,000	.....
4	2457	1520	1110	.....	.....	.....
5	4546	.....	2180	.....	.....	.....
6	7462	.....	.....	.....	.....	.....

Copyright, 1927 { AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS / *Heating and Piping Contractors National Association* } **Not to be Reprinted Without Special Permission**

*Radiator branches more than 8 ft. in length should be *one* size larger than shown in Col. *D*.

Note 1.—These tables apply where pipes are properly reamed. No allowances for defective material or workmanship have been made. (Also see Tables 8 and 9).

Note 2.—Capacities based on ¼ lb. condensation per square foot per hour equivalent radiation and actual diameter of standard pipe.

Note 3.—Extra length to be added to straight run of pipe, for various fittings and valves to determine equivalent length. (See Table 4).

Note 4.—Where it is necessary to drip a steam main, branch to riser or riser, same should be dripped separately into wet return.

Note 5.—Pitch of mains should be not less than ¼ in. in 10 ft.; on horizontal branches to radiators and risers at least ½ in. in 10 ft.

upon a total pressure drop in the entire equivalent length from steam supply to farthest heating unit of 4 oz. Up-feed risers, branches to risers and heating units should not be loaded beyond the maximum capacities given in Columns *H* and *I*.

Table 18 is similar to Table 17 and is for larger systems where the equivalent length of run ranges up to 1200 ft. It is based on a total pressure drop of 8 oz. in the entire equivalent length.

In designing any kind of a heating system it is well to avoid excessive pressure drop in any part of the system. While, under proper design and good workmanship, higher drop may give good results, it is generally not considered good practice to exceed a drop of 1 oz. in 100 ft. equivalent length.

TABLE 11. PIPE SIZES FOR TWO-PIPE, GRAVITY, LOW PRESSURE STEAM, WHERE EQUIVALENT LENGTH OF RUN FROM BOILER OR SOURCE OF SUPPLY TO FARTHEST RADIATOR DOES NOT EXCEED 200 FT.

Capacity in Sq. Ft. of Equivalent Radiation

Based on Total Pressure Drop of 1 oz. per 100 ft.

Pipe Sizes Inches	Supply Main Dripped and Branches to Risers Dripped Steam and Condensate Flowing in same Direction	Supply Risers Up-Feed	Branches to Supply Risers and Radiators Not Dripped	Return Risers	Wet Return Main	Dry Return Main	Radiator Supply Valve	Radiator Return Valve
A	*B*	*C*	*D**	*E*	*F*	*G*	*H*	*I*
¾	....	30	....	122	.....	.....	30	122
1	56	56	26	320	700	320	56	190
1¼	122	122	58	670	1200	670	122	386
1½	190	190	95	1058	1900	1058	190	.....
2	386	386	195	2300	4000	2300	386	.....
2½	635	635	395	3800	6700	3800	.....	.....
3	1163	1129	700	7000	10,700	7000	.....	.....
3½	1737	1548	1150	10,000	.....	10,000	.....	.....
4	2457	2042	1700	.....	.....	.....	.....	.....
5	4546	.....	3150	.....	.....	.....	.....	.....
6	7462	.....	.....	.....	.....	.....	.....	.....

Copyright, 1927 { AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS / *Heating and Piping Contractors National Association* } **Not to be Reprinted Without Special Permission**

*Radiator branches more than 8 ft. in length should be *one* size larger than shown in Col. *D*.

Note 1.—These tables apply where pipes are properly reamed. No allowances for defective material or workmanship have been made. (Also see Tables 8 and 9).

Note 2.—Capacities based on ¼ lb. condensation per square foot per hour equivalent radiation and actual diameter of standard pipe.

Note 3.—Extra length to be added to straight run of pipe for various fittings and valves to determine equivalent length. (See Table 4.)

Note 4.—Where it is necessary to drip a supply main, supply riser or branch to a supply riser, same should be dripped separately into a wet return or through an adequate seal into a dry return. Never drip a supply pipe into a dry return except through an adequate seal.

Note 5.—Pitch of mains should not be less than ¼ in. in 10 ft.; on horizontal branches to radiators and risers at least ½ in. in 10 ft.

If it is desired to determine the capacity of a pipe for any other length than 100 ft. or for any initial pressure other than 1 lb. Tables 2 and 3 are used.

To determine the capacity of any pipe under initial pressure other than 1 lb., multiply the capacity given in Table 2 by the pressure factor in Column 2 opposite the required pressure indicated in Column 1.

To determine the capacity for any length other than 100 ft., multiply the capacity given in Table 2 by the length factor in Column *B* opposite the required length in Column *A*.

Example.—What is the capacity of a 140 ft. 4 in. pipe with an initial pressure of 1 lb. and pressure drop of 2 oz. in the 140 ft.?

Solution.—From Table 2 it is found that the capacity of a 100 ft. 4 in. pipe with 1 lb. initial pressure and 2 oz. pressure drop, is 3475 sq. ft. Multiplying this value by 0.841 the constant for a 140 ft. length as given in Table 3 gives 2922 the capacity for the given conditions.

Example.—What is the capacity of a 100 ft. 4 in. pipe with 2 lb. initial pressure and pressure drop of 1 oz.?

Solution.—From Table 2, find 2457, the capacity of the 4 in. pipe with 1 lb. initial pressure and 1 oz. pressure drop. Multiplying 2457 by 1.03 the constant found in Column 2 of Table 3 for 2 lb. initial pressure gives 2531 as the capacity of the 4 in. pipe with 2 lb. initial pressure and a pressure drop of 1 oz. per 100 ft. length.

Example.—What is the capacity of a 140 ft. 4 in. pipe with 2 lb. initial pressure and a pressure drop of 2 oz.?

Solution.—From Table 2 find 3475, the capacity of the 4 in. pipe with 1 lb. initial pressure and 2 oz. pressure drop. Multiplying 3475 by 1.03 the constant found in Column 2 for 2 lb. initial pressure and this by 0.841 the constant found under Column *B* the constant for 140 ft. length all as given in Table 3 gives 3010 as the capacity of the 4 in. pipe with 2 lb. initial pressure and a pressure drop of 2 oz. in the 140 ft. length.

Should lengths other than those given in Column *A* Table 3 and under length of pipes in feet in Table 1 be desired the constant may be obtained from the formula in Column 4 Table 1.

Example.—What would be the constant for 2500 ft. of pipe to be used either in Table 1 or 3?

Solution.—The $\sqrt{\frac{100}{2500}} = 0.2$ or the constant to be used.

In determining the length of pipe used in any system, the actual length must be increased for the various fittings, and valves, in determining the equivalent length before applying any of the tables given.

Gate valves are recommended in all cases where the service calls for the valve to be either entirely closed or open. They should never be used for throttling. Angle and globe valves should be used for throttling such as the by-pass valve in a pressure reducing outfit.

These tables are all based on the latest available scientific data with the idea of conserving pipe sizes as far as possible but without in any way jeopardizing proper operation. In this connection it has been assumed that all pipes will be reamed, that the piping will be properly pitched and in every respect will be of good construction and workmanship. It is recommended that pipes be not loaded beyond the capacities given.

In using these tables special care should be taken to read the headings describing the system, the pressure drop, etc., and particular attention should be given to the footnotes. Observation of these rules will make the effective application of these tables easy and save much time for the user.

TABLE 12. PIPE SIZES FOR TWO-PIPE, GRAVITY, VAPOR† SYSTEMS, WHERE EQUIVALENT LENGTH OF RUN FROM BOILER OR SOURCE OF SUPPLY TO FARTHEST RADIATOR DOES NOT EXCEED 200 FT.

Capacity in Sq. Ft. of Equivalent Radiation

Based on Total Pressure Drop of 1 oz. per 100 ft.

Pipe Size Inches	Supply Main Dripped and Branches to Risers Dripped. Steam and Condensate flowing in same direction.	Supply Risers Up-Feed	Branches to Supply Risers and Radiators Not Dripped *	Return Risers	Wet Return Main	Dry Return Main
A	*B*	*C*	*D**	*E*	*F*	*G*
¾	---	30	---	190	-----	-----
1	56	56	26	450	700	320
1¼	122	122	58	990	1200	670
1½	190	190	95	1500	1900	1058
2	386	386	195	3000	4000	2300
2½	635	635	395	-----	6700	3800
3	1163	1129	700	-----	10,700	7000
3½	1737	1548	1150	-----	-----	10,000
4	2457	2042	1700	-----	-----	-----
5	4546	-----	3150	-----	-----	-----
6	7462	**Different makes of supply and return valves, steam traps and other specialties vary as to capacity, therefore use size as recommended for any particular make. Vertical connections to be of same size as valve and trap used. Return horizontal runout to be not less than ¾ in.**				

Copyright, 1927 { AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS / *Heating and Piping Contractors National Association* } Not to be Reprinted Without Special Permission

*Radiator branches more than 8 ft. in length should be *one* size larger than shown in Col. *D*.

†This table is for systems which are open to atmosphere or operate under slight pressure or partial vacuum without use of vacuum pumps.

Note 1.—These tables apply where pipes are properly reamed. No allowances for defective material or workmanship have been made. (Also see Tables 8 and 9).

Note 2.—Capacities based on ¼ lb. condensation per square foot per hour equivalent radiation and actual diameter of standard pipe.

Note 3.—Extra length to be added to straight run of pipe for various fittings and valves to determine equivalent length. (See Table 4.)

Note 4.—Where it is necessary to drip a supply main, supply riser or branch to a supply riser, same should be dripped separately into a wet return. The drip for a vapor or vacuum system may be taken into a dry return through a steam trap.

Note 5.—Pitch of mains should be not less than ¼ in in 10 ft.; on horizontal branches to radiators and risers at least ½ in. in 10 ft.

Table 13. Pipe Sizes for One-Pipe, Gravity, Low Pressure Steam Heating Systems, where Equivalent Length of Run from Boiler or Source of Supply to Farthest Radiator Exceeds 200 Ft.

Capacity in Sq. Ft. of Equivalent Radiation

Pipe Size Inches	Equivalent Length of Pipe from Boiler to Farthest Radiator, Including Main and Riser. (See *Note 4.*) Supply Main Dripped and Branches to Risers Dripped—Steam and Condensate flowing in same direction. Based on 4 oz. Total Pressure Drop						Maximum Capacities		
	100 Ft.	200 Ft.	300 Ft.	400 Ft.	500 Ft.	600 Ft.	Supply Risers Up-Feed	Branches to Supply Risers and Radiators Not Dripped	Radiator Valves and Vertical Connections
A	*B*	*C*	*D*	*E*	*F*	*G*	*H*	*I**	*J*
1	111	79	65	56	49	46	45	20	20
1¼	245	173	141	122	110	100	98	55	55
1½	380	269	220	190	165	155	152	81	81
2	771	546	446	386	345	315	288	165	165
2½	1270	898	734	635	568	518	464	260	.....
3	2326	1645	1342	1163	1040	948	799	475	.....
3½	3474	2457	2006	1737	1552	1419	1144	745	.....
4	4914	3475	2828	2457	2196	2011	1520	1110	.....
5	9092	6429	5250	4546	4062	3712	.....	2180	.....
6	14,924	10,553	8618	7462	6669	6094	.....	.....	.....
8	31,066	21,967	17,935	15,533	13,880	12,682	.....	.....	.....
10	56,689	40,085	32,730	28,345	25,334	23,144	.....	.....	.....
12	90,985	64,336	52,530	45,492	40,660	37,145	.....	.....	.....

Pipe Size Inches	Dry Return Main. Equivalent Length of Run from Boiler to Foot of Farthest Riser in Feet						Wet Return Main. Equivalent Length of Run from Boiler to Foot of Farthest Riser in Feet					
	100	200	300	400	500	600	100	200	300	400	500	600
K	*L*	*M*	*N*	*O*	*P*	*Q*	*R*	*S*	*T*	*U*	*V*	*W*
1	460	412	368	320	275	227	1400	1000	820	700	640	580
1¼	962	868	770	670	579	480	2400	1700	1390	1200	1080	990
1½	1512	1362	1210	1058	909	757	3800	2700	2180	1900	1710	1570
2	3300	2960	2640	2300	1980	1630	8000	5600	4520	4000	3560	3240
2½	5450	4900	4380	3800	3300	2770	13,400	9400	7600	6700	6000	5300
3	10,000	9000	8000	7000	6000	5000	21,400	15,000	12,500	10,700	9400	8500
3½	14,300	12,900	11,500	10,000	8600	7200	32,000	22,000	18,500	16,000	14,400	13,200
4	21,500	19,300	17,200	15,000	12,900	10,700	44,000	31,000	25,500	22,000	19,900	18,300

Copyright, 1927 { American Society of Heating and Ventilating Engineers / *Heating and Piping Contractors National Association* } Not to be Reprinted Without Special Permission

*Radiator branches more than 8 ft. in length should be *one* size larger than shown in Column *I*.

Note 1.—These tables apply where pipes are properly reamed. No allowances for defective material or workmanship have been made. (Also see Tables 8 and 9).

Note 2.—Capacities based on ¼ lb. condensation per square foot per hour equivalent radiation and actual diameter of standard pipe.

Note 3.—Extra length to be added to straight run of pipe for various fittings and valves to determine equivalent length, (See Table 4).

Note 4.—Mains are to be proportioned according to the equivalent length of run from the boiler or source of supply to the farthest radiators supplied by the main.

Determine equivalent length of run then use figures in that corresponding Column (*B* to *G*) for supply mains; (*L* to *Q*) for dry return mains; (*R* to *W*) for wet return mains for sizing the entire run.

Risers are to be proportioned according to the equivalent length of run from the boiler or source of supply to the farthest radiator on each particular riser.

Determine the distance to the farthest radiator then use the figures in the corresponding Column (*B* to *G*) for sizing each riser; providing the amount of radiation for that riser does not exceed amounts shown in Column *H*. Where riser capacities are found to be in excess of amounts in Column *H*. step up to necessary size indicated in that column.

Note 5.—Where it is necessary to drip a steam main, branch to riser or riser, same should be dripped separately into wet return.

Note 6.—Pitch of mains should be not less than ¼ in. in 10 ft.; on horizontal branches to radiators and risers at least ½ in. in 10 ft.

Table 14. Pipe Sizes for Two-Pipe, Gravity, Low Pressure Steam Heating Systems where Equivalent Length of Run from Boiler or Source of Supply to Farthest Radiator Exceeds 200 Ft.

Capacity in Sq. Ft. Equivalent Radiation

Pipe Size Inches	Equivalent Length of Pipe from Boiler to Farthest Radiator, Including Main and Riser. (See *Note 4.*) Supply Main Dripped and Branches to Risers Dripped—Steam and Condensate flowing in same direction Based on 4 oz. Total Pressure Drop						Maximum Capacities			
	100 Ft.	200 Ft.	300 Ft.	400 Ft.	500 Ft.	600 Ft.	Supply Risers Up-Feed	Branches to Supply Risers and Radiators Not Dripped	Rad. Supply Valves and Vertical Connections	Radiator Return Valves and Connections
A	*B*	*C*	*D*	*E*	*F*	*G*	*H*	*I**	*J*	*K*
¾	.....	.....	.....	.....	.....	.....	30	.....	30	122
1	111	79	65	56	49	46	56	26	56	190
1¼	245	173	141	122	110	100	122	58	122	386
1½	380	269	220	190	165	155	190	95	190	.....
2	771	546	446	386	345	315	386	195	386	.....
2½	1270	898	734	635	568	518	635	395	.....	.....
3	2326	1645	1342	1163	1040	948	1129	700	.....	.....
3½	3474	2457	2006	1737	1552	1419	1548	1150	.....	.....
4	4914	3475	2828	2457	2196	2011	2042	1700	.....	.....
5	9092	6429	5250	4546	4062	3712	.....	3150	.....	.....
6	14,924	10,553	8618	7462	6669	6094	.....	.....	.....	.....
8	31,066	21,967	17,935	15,533	13,880	12,682	.....	.....	.....	.....
10	56,689	40,085	32,730	28,345	25,334	23,144	.....	.....	.....	.....
12	90,985	64,336	52,530	45,492	40,660	37,145	.....	.....	.....	.....

Pipe Size Inches	Dry Return Main. Equivalent Length of Run from Boiler to Farthest Radiator in Feet						Wet Return Main. Equivalent Length of Run from Boiler to Farthest Radiator in Feet					
	100	200	300	400	500	600	100	200	300	400	500	600
M	*N*	*O*	*P*	*Q*	*R*	*S*	*T*	*U*	*V*	*W*	*X*	*Y*
1	460	412	368	320	275	227	1400	1000	820	700	640	580
1¼	962	868	770	670	579	480	2400	1700	1390	1200	1080	990
1½	1512	1362	1210	1058	909	757	3800	2700	2180	1900	1710	1570
2	3300	2960	2640	2300	1980	1630	8000	5600	4520	4000	3460	3240
2½	5450	4900	4380	3800	3300	2770	13,400	9400	7600	6700	6000	5300
3	10,000	9000	8000	7000	6000	5000	21,400	15,000	12,500	10,700	9400	8500
3½	14,300	12,900	11,500	10,000	8600	7200	32,000	22,000	18,500	16,000	14,400	13,200
4	21,500	19,300	17,200	15,000	12,900	10,700	44,000	31,000	25,500	22,000	19,900	18,300

Copyright, 1927 { American Society of Heating and Ventilating Engineers / *Heating and Piping Contractors National Association* } Not to be Reprinted Without Special Permission

*Radiator branches more than 8 ft. in length should be *one* size larger than shown in Column *I*.

Note 1.—These tables apply where pipes are properly reamed. No allowances for defective material or workmanship have been made. (Also see Tables 8 and 9).

Note 2.—Capacities based on ¼ lb. condensation per square foot per hour equivalent radiation and actual diameter of standard pipe.

Note 3.—Extra length to be added to straight run of pipe for various fittings and valves to determine equivalent length. (See Table 4).

Note 4.—Mains are to be proportioned according to the equivalent length of run from the boiler or source of supply to the farthest radiators supplied by the main.

Determine equivalent length of run then use figures in that corresponding Column (*B* to *G*) for supply mains; (*N* to *S*) for dry return mains; (*T* to *Y*) for wet return mains for sizing the entire run.

Supply and return risers are to be proportioned according to the equivalent length of run from the boiler or source of supply to the farthest radiator on each riser.

For supply risers determine the distance from the boiler to the farthest radiator served by that riser then use the figures in the corresponding Column (*B* to *G*) for sizing each supply riser; providing the amount of radiation for that riser does not exceed amounts shown in Column *H*. Where supply riser capacities are found to be in excess of amounts shown in Column *H*, step up to necessary size indicated in that column. For return risers determine the equivalent length of run in feet from the top of each riser to the boiler then use the figures in the corresponding Columns (*N* to *S*) for sizing each riser.

Note 5.—Where it is necessary to drip a supply main or a supply riser or a branch to a supply riser, same should drip separately into a wet return. A drip for a two-pipe system may be taken into a dry return through an adequate seal.

Note 6.—Pitch of mains should be not less than ¼ in. in 10 ft.; on horizontal branches to radiators and risers at least ½ in. in 10 ft.

TABLE 15. PIPE SIZES FOR TWO-PIPE VAPOR† HEATING SYSTEMS, WHERE EQUIVALENT LENGTH OF RUN FROM BOILER OR SOURCE OF SUPPLY TO FARTHEST RADIATOR Exceeds 200 FT.

Capacity in Sq. Ft. Equivalent Radiation

PIPE SIZE INCHES	EQUIVALENT LENGTH OF PIPE FROM BOILER TO FARTHEST RADIATOR, INCLUDING MAIN AND RISER. (See *Note 4.*) Supply Main Dripped and Branches to Risers Dripped—Steam and Condensate flowing in same direction. **Based on 2 oz. Total Pressure Drop**				MAXIMUM CAPACITIES		
	100 Ft.	200 Ft.	300 Ft.	400 Ft.	Supply Risers Up-Feed	Branches to Supply Risers and Radiators Not Dripped	Return Risers
A	*B*	*C*	*D*	*E*	*F*	*G**	*H*
¾	....	....	....	....	30	....	190
1	79	56	46	39	56	26	450
1¼	173	122	100	87	122	58	990
1½	269	190	155	134	190	95	1500
2	546	386	315	273	386	195	3000
2½	898	635	518	449	635	395	.....
3	1645	1163	948	822	1129	700	.....
3½	2457	1737	1419	1228	1548	1150	.....
4	3475	2457	2011	1738	2042	1700	.....
5	6929	4546	3712	3214	.....	3150	.....
6	10,553	7462	6094	5276			
8	21,967	15,533	12,682	10,983			
10	40,085	23,345	23,144	20,043			
12	64,336	45,492	37,145	32,168			

Different makes of supply and return valves, steam traps and other specialties vary as to capacity, therefore use size as recommended for any particular make. Vertical connections to be of same size as valve and trap used. Return horizontal runout to be not less than ¼ in.

PIPE SIZE INCHES	DRY RETURN MAIN — EQUIVALENT LENGTH OF RUN FROM BOILER TO FARTHEST RADIATOR IN FEET				WET RETURN MAIN — EQUIVALENT LENGTH OF RUN FROM BOILER TO FARTHEST RADIATOR IN FEET			
	100	200	300	400	100	200	300	400
I	*J*	*K*	*L*	*M*	*N*	*O*	*P*	*Q*
1	355	320	285	248	1000	700	580	500
1¼	745	670	595	520	1700	1200	990	850
1½	1173	1058	943	822	2700	1900	1570	1350
2	2680	2300	2140	1880	5600	4000	3240	2800
2½	4300	3800	3470	3040	9400	6700	5300	4700
3	7800	7000	6250	5480	15,000	10,700	8500	7500
3½	11,100	10,000	8800	7880	22,000	16,000	13,200	11,000
4	16,700	15,000	13,400	11,700	31,000	22,000	18,300	15,500

Copyright, 1927 { AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS / *Heating and Piping Contractors National Association* } **Not to be Reprinted Without Special Permission**

*Radiator branches more than 8 ft. in length should be *one* size larger than shown in Column *G*.

†This table is for systems which are open to atmosphere or operate under slight pressure or partial vacuum without use of vacuum pumps.

Note 1.—These tables apply where pipes are properly reamed. No allowances for defective material or workmanship have been made. (Also see Tables 8 and 9).

Note 2.—Capacities based on ¼ lb. condensation per square foot per hour equivalent radiation and actual diameter of standard pipe.

Note 3.—Extra length to be added to straight run of pipe for various fittings and valves to determine equivalent length. (See Table 4).

Note 4.—Mains are to be proportioned according to the equivalent length of run from the boiler or source of supply to the farthest radiators supplied by the main.

Determine equivalent length of run then use figures in that corresponding Column (*B* to *E*) for supply mains; (*J* to *M*) for dry return mains; (*N* to *Q*) for wet return mains for sizing the entire run.

Supply and return risers are to be proportioned according to the equivalent length of run from the boiler or source of supply to the farthest radiator on each riser.

For supply risers determine the distance from the boiler to the farthest radiator served by that riser then use the figures in the corresponding Column (*B* to *E*) for sizing each supply riser; providing the amount of radiation for that riser does not exceed amounts shown in Column *F*. Where supply riser capacities are found to be in excess of amounts shown in Column *F*, step up to necessary size indicated in that column. For return risers determine the equivalent length of run in feet from the top of each riser to the boiler then use the figures in the corresponding Columns (*J* to *M*) for sizing each riser.

Note 5.—Where it is necessary to drip a supply main or a supply riser or a branch to a supply riser, same should drip separately into a wet return. The drip for a vapor or vacuum system may be taken into a dry return through a steam trap.

Note 6.—Pitch of mains should be not less than ¼ in. in 10 ft.; on horizontal branches to radiators and risers at least ½ in. in 10 ft.

TABLE 16. PIPE SIZES FOR TWO-PIPE VAPOR† HEATING SYSTEMS, WHERE EQUIVALENT LENGTH OF RUN FROM BOILER OR SOURCE OF SUPPLY TO FARTHEST RADIATOR Exceeds 200 FT.

Capacity in Sq. Ft. of Equivalent Radiation

PIPE SIZE INCHES	EQUIVALENT LENGTH OF PIPE FROM BOILER TO FARTHEST RADIATOR, INCLUDING MAIN AND RISER. (See *Note 4.*) Supply Main Dripped and Branches to Risers Dripped—Steam and Condensate flowing in same direction. **Based on 4 oz. Total Pressure Drop**						MAXIMUM CAPACITIES		
	100 Ft.	200 Ft.	300 Ft.	400 Ft.	500 Ft.	600 Ft.	Supply Risers Up-Feed	Branches to Supply Risers and Radiators Not Dripped	Return Risers
A	*B*	*C*	*D*	*E*	*F*	*G*	*H*	*I**	*J*
¾	.....	....	....	....	....	....	30	....	190
1	111	79	65	56	49	46	56	26	450
1¼	245	173	141	122	110	100	122	58	990
1½	380	269	220	190	165	155	190	95	1500
2	771	546	446	386	345	315	386	195	3000
2½	1270	898	734	635	568	518	635	395	.....
3	2326	1645	1342	1163	1040	948	1129	700	.....
3½	3474	2457	2006	1737	1552	1419	1548	1150	.....
4	4914	3475	2828	2457	2196	2011	2042	1700	.....
5	9092	6429	5250	4546	4062	3712	.....	3150	.....
6	14,924	10,553	8618	7462	6669	6094			
8	31,066	21,967	17,935	15,533	13,880	12,682			
10	56,689	40,085	32,730	28,345	25,334	23,144			
12	90,985	64,336	52,530	45,492	40,660	37,145			

Different makes of supply and return valves, steam traps and other specialties vary as to capacity, therefore use size as recommended for any particular make. Vertical connections to be of same size as valve and trap used. Return horizontal runout to be not less than ¼ in.

PIPE SIZE INCHES	DRY RETURN MAIN — EQUIVALENT LENGTH OF RUN FROM BOILER TO FARTHEST RADIATOR IN FEET						WET RETURN MAIN — EQUIVALENT LENGTH OF RUN FROM BOILER TO FARTHEST RADIATOR IN FEET					
	100	200	300	400	500	600	100	200	300	400	500	600
K	*L*	*M*	*N*	*O*	*P*	*Q*	*R*	*S*	*T*	*U*	*V*	*W*
1	460	412	368	320	275	227	1400	1000	820	700	590	480
1¼	962	868	770	670	579	480	2400	1700	1420	1200	1020	860
1½	1512	1362	1210	1058	909	757	3800	2700	2260	1900	1560	1300
2	3300	2960	2640	2300	1980	1630	8000	5600	4500	4000	3360	2800
2½	5450	4900	4380	3800	3300	2770	13,400	9400	7600	6700	5700	4800
3	10,000	9000	8000	7000	6000	5000	21,400	15,000	12,300	10,700	9300	7800
3½	14,300	12,900	11,500	10,000	8600	7200	32,000	22,000	24,000	16,000	13,600	11,400
4	21,500	19,300	17,200	15,000	12,900	10,700	44,000	31,000	26,000	22,000	20,500	15,400

Copyright, 1927 { AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS / *Heating and Piping Contractors National Association* } **Not to be Reprinted Without Special Permission**

*Radiator branches more than 8 ft. in length should be *one* size larger than shown in Column *I*.

†This table is for systems which are open to atmosphere or operate under slight pressure or partial vacuum without use of vacuum pumps.

Note 1.—These tables apply where pipes are properly reamed. No allowances for defective material or workmanship have been made. (Also see Tables 8 and 9).

Note 2.—Capacities based on ¼ lb. condensation per square foot per hour equivalent radiation and actual diameter of standard pipe.

Note 3.—Extra length to be added to straight run of pipe for various fittings and valves to determine equivalent length. (See Table 4).

Note 4.—Mains are to be proportioned according to the equivalent length of run from the boiler or source of supply to the farthest radiators supplied by the main.

Determine equivalent length of run then use figures in that corresponding Column (*B* to *G*) for supply mains; (*L* to *Q*) for dry return mains; (*R* to *W*) for wet return mains for sizing the entire run.

Supply and return risers are to be proportioned according to the equivalent length of run from the boiler or source of supply to the farthest radiator on each riser.

For supply risers determine the distance from the boiler to the farthest radiator served by that riser then use the figures in the corresponding Column (*B* to *G*) for sizing each supply riser; providing the amount of radiation for that riser does not exceed amounts shown in Column *H*. Where supply riser capacities are found to be in excess of amounts shown in Column *H*, step up to necessary size indicated in that column. For return risers determine the equivalent length of run in feet from the top of each riser to the boiler then use the figures in the corresponding Columns (*L* to *Q*) for sizing each riser.

Note 5.—Where it is necessary to drip a supply main or a supply riser or a branch to a supply riser, same should drip separately into a wet return. The drip for a vapor or a vacuum system may be taken into a dry return through a steam trap.

Note 6.—Pitch of mains should be not less than ¼ in. in 10 ft.; on horizontal branches to radiators and risers at least ½ in. in 10 ft.

Table 17. Pipe Sizes for Vacuum Pump Systems, where Equivalent Length of Run from Boiler or Source of Supply to Farthest Radiator Exceeds 200 Ft.

Capacity in Sq. Ft. of Equivalent Radiation

Pipe Size Inches	Equivalent Length of Pipe from Boiler to Farthest Radiator, Including Main and Riser. (See *Note 4.*) Supply Main Dripped and Branches to Risers Dripped—Steam and Condensate flowing in same direction. **Based on 4 oz. Total Pressure Drop****						Maximum Capacities	
	100 Ft.	200 Ft.	300 Ft.	400 Ft.	500 Ft.	600 Ft.	Supply Risers Up-Feed	Branches to Supply Risers and Radiators Not Dripped
A	*B*	*C*	*D*	*E*	*F*	*G*	*H*	*I**
¾	.....	....	....	....	....	....	....	....
1	111	79	65	56	49	46	56	26
1¼	245	173	141	122	110	100	122	58
1½	380	269	220	190	165	155	190	95
2	771	546	446	386	345	315	386	195
2½	1270	898	734	635	568	518	635	395
3	2326	1645	1342	1163	1040	948	1129	700
3½	3474	2457	2006	1737	1552	1419	1548	1150
4	4914	3475	2828	2457	2196	2011	2042	1700
5	9092	6429	5250	4546	4062	3712		3150
6	14,924	10,553	8618	7462	6669	6094	.....	.....
8	31,066	21,967	17,935	15,533	13,880	12,682	.....	.....
10	56,689	40,085	32,730	28,345	25,334	23,144	.....	.....
12	90,985	64,336	52,530	45,492	40,660	37,145	.....	.....

Pipe Size Inches		Return Mains and Risers					
Riser	Main	100 Ft.	200 Ft.	300 Ft.	400 Ft.	500 Ft.	600 Ft.
J	*K*	*L*	*M*	*N*	*O*	*P*	*Q*
....	¾	800	568	462	400	358	326
¾	1	1400	994	810	700	626	570
1	1¼	2400	1704	1387	1200	1073	976
1¼	1½	3800	2696	2195	1900	1698	1547
1½	2	8000	5680	4622	4000	3575	3256
2	2½	13,400	9510	7745	6700	5990	5453
2½	3	21,400	15,190	12,360	10,700	9565	8710
3	3½	32,000	22,710	18,490	16,000	14,300	13,020
3½	4	44,000	31,220	25,430	22,000	19,660	17,910

Different makes of supply and return valves, steam traps and other specialties vary as to capacity, therefore use size as recommended for any particular make. Vertical connection to be of same size as valve and trap used. Return horizontal runout to be no less than ¾ in.

Copyright, 1927 { American Society of Heating and Ventilating Engineers / Heating and Piping Contractors National Association } Not to be Reprinted Without Special Permission

*Radiator branches more than 8 ft. in length should be *one* size larger than shown in Column *I*.

**It is not generally considered good practice to greatly exceed 1 oz. drop in pressure in each 100 ft. equivalent length of run nor to exceed 1 lb. total pressure drop in any system.

Note 1.—These tables apply where pipes are properly reamed. No allowances for defective material or workmanship have been made. (Also see Tables 8 and 9).

Note 2.—Capacities based on ¼ lb. condensation per square foot per hour equivalent radiation and actual diameter of standard pipe.

Note 3.—Extra length to be added to straight run of pipe, for various fittings and valves to determine equivalent length. (See Table 4).

Note 4.—Mains are to be proportioned according to the equivalent length of run from the boiler or source of supply to the farthest radiators supplied by the main.

Determine equivalent length of run then use figures in corresponding Column (*B* to *G*) for sizing the entire run.

Supply risers are to be proportioned according to the equivalent length of run from the boiler or source of supply to the farthest radiator on each riser. Determine the distance to the farthest radiator then use figures in that corresponding Column (*B* to *G*) for sizing each riser; providing the amount of radiation for that riser does not exceed amounts shown in Column *H*. Where riser capacities are found to be in excess of amounts shown in Column *H*, step up to necessary size indicated in that column.

Note 5.—Return mains and risers are to be proportioned according to the equivalent distance in feet, from farthest radiator to the vacuum pump; using capacities in that corresponding Column (*L* to *Q*) for sizing entire return riser (Column *J*) and return main (Column *K*). *The return pipe sizes are conservative and are subject to revision upon the completion of pending research investigations.*

Note 6.—Where it is necessary to drip a supply main, supply riser or branch to a supply riser, same should be dripped separately through a steam trap into vacuum return. Never drip a supply riser into a vacuum return except through a steam trap.

Note 7.—Lift fittings. (See page 109).

Note 8.—Pitch of mains should be not less than ¼ in. in 10 ft.; on horizontal branches to radiators and risers at least ½ in. in 10 ft.

Table 18. Pipe Sizes for Vacuum Pump Systems, where Equivalent Length of Run from Boiler or Source of Supply to Farthest Radiator Exceeds 200 Ft.

Capacity in Sq. Ft. of Equivalent Radiation

Pipe Size In.	Equivalent Length of Pipe from Boiler to Farthest Radiator, Including Main and Riser. (See *Note 4.*) Supply Main Dripped and Branches to Risers Dripped—Steam and Condensate flowing in same direction. **Based on 8 oz. Total Pressure Drop****									Maximum Capacities	
	100 Ft.	200 Ft.	300 Ft.	400 Ft.	500 Ft.	600 Ft.	800 Ft.	1000 Ft.	1200 Ft.	Supply Risers Up-Feed	Branches to Supply Risers and Radiators Not Dripped
A	*B*	*C*	*D*	*E*	*F*	*G*	*H*	*I*	*J*	*K*	*L**
1	157	111	92	79	70	65	56	49	46	56	26
1¼	346	245	200	173	154	141	122	110	100	122	58
1½	538	380	310	269	240	220	190	165	155	190	95
2	1091	771	630	546	487	446	386	345	315	386	195
2½	1797	1270	1036	898	803	734	635	568	518	635	395
3	3289	2326	1896	1645	1470	1342	1163	1040	948	1129	700
3½	4913	3474	2838	2457	2196	2006	1737	1552	1419	1548	1150
4	6950	4914	4022	3475	3106	2828	2457	2196	2011	2042	1700
5	12,858	9092	7424	6429	5747	5250	4546	4062	3712	.....	3150
6	21,105	14,924	12,168	10,553	9433	8618	7462	6669	6084	.....	.....
8	43,934	31,066	25,364	21,967	19,638	17,935	15,533	13,880	12,682	.....	.....
10	80,171	56,689	46,288	40,085	35,836	32,730	28,345	25,334	23,144	.....	.....
12	128,672	90,985	74,290	64,336	57,516	52,530	45,492	40,660	37,145	.....	.....
16	240,245	169,879	138,381	121,012	107,389	98,500	84,849	75,917	69,671	.....	.....

Pipe Size Inches		Return Mains and Risers								
Riser	Main	100 Ft.	200 Ft.	300 Ft.	400 Ft.	500 Ft.	600 Ft.	800 Ft.	1000 Ft.	1200 Ft.
M	*N*	*O*	*P*	*Q*	*R*	*S*	*T*	*U*	*V*	*W*
....	¾	1130	800	653	568	505	462	400	358	326
¾	1	1977	1400	1143	994	884	810	700	626	570
1	1¼	3390	2400	1960	1704	1515	1387	1200	1073	976
1¼	1½	5370	3800	3103	2696	2400	2195	1900	1698	1547
1½	2	11,300	8000	6533	5680	5050	4622	4000	3575	3256
2	2½	18,925	13,400	10,940	9510	8460	7745	6700	5990	5453
2½	3	30,230	21,400	17,460	15,190	13,510	12,360	10,700	9565	8710
3	3½	45,200	32,000	26,130	22,710	20,200	18,490	16,000	14,300	13,020
3½	4	62,180	44,000	35,950	31,220	27,800	25,430	22,000	19,660	17,910
4	5	109,300	77,400	63,200	54,920	48,800	44,720	38,700	34,600	31,500
5	6	175,100	124,000	101,200	88,000	78,200	71,700	62,000	55,410	50,450

Different makes of supply and return valves, steam traps and other specialties vary as to capacity, therefore use size as recommended for any particular make. Vertical connection to be of same size as valve and trap used. Return horizontal runout to be not less than ¾ in.

Copyright, 1927 { American Society of Heating and Ventilating Engineers / Heating and Piping Contractors National Association } Not to be Reprinted Without Special Permission

*Radiator branches more than 8 ft. in length should be *one* size larger than shown in Column *L*.

**It is not generally considered good practice to greatly exceed 1 oz. drop in pressure in each 100 ft. equivalent length of run nor to exceed 1 lb. total pressure drop in any system.

Note 1.—These tables apply where pipes are properly reamed. No allowances for defective material or workmanship have been made. (Also see Tables 8 and 9).

Note 2.—Capacities based on ¼ lb. condensation per square foot per hour equivalent radiation and actual diameter of standard pipe.

Note 3.—Extra length to be added to straight run of pipe, for various fittings and valves to determine equivalent length. (See Table 4).

Note 4.—Mains are to be proportioned according to the equivalent length of run from the boiler or source of supply to the farthest radiators supplied by the main.

Determine equivalent length of run then use figures in corresponding Column (*B* to *J*) for sizing the entire run.

Supply risers are to be proportioned according to the equivalent length of run from the boiler or source of supply to the farthest radiator on each particular riser. Determine the distance to the farthest radiator then use figures in that corresponding Column (*B* to *J*) for sizing each riser; providing the amount of radiation for that riser does not exceed amounts shown in Column *K*. Where riser capacities are found to be in excess of amounts shown in Column *K*, step up to necessary size indicated in that column.

Note 5.—Return mains and risers are to be proportioned according to the equivalent distance in feet, from farthest radiator to the vacuum pump; using capacities in that corresponding Column (*O* to *W*) for sizing entire return riser (Column *M*) and return main (Column *N*). *The return pipe sizes are conservative and are subject to revision upon the completion of pending research investigations.*

Note 6.—*Where it is necessary to drip a supply main, supply riser or branch to a supply riser, same should be dripped separately through* a steam trap into vacuum return. Never drip a supply riser into a vacuum return except through a steam trap.

Note 7.—Lift fittings. (See page 109).

Note 8.—Pitch of mains should be not less than ¼ in. in 10 ft.; on horizontal branches to radiators and risers at least ½ in. in 10 ft.

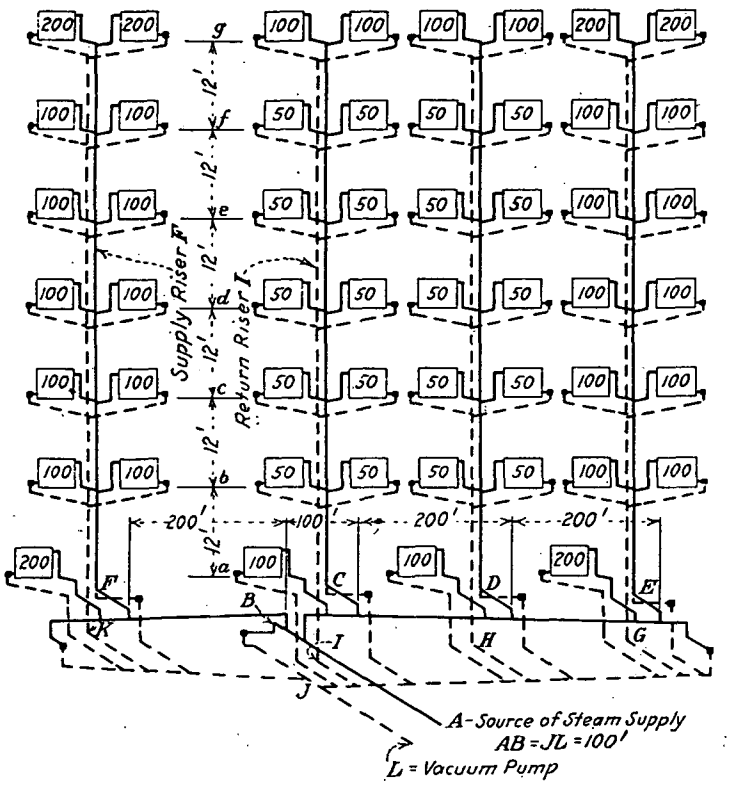


FIG. 8 LAYOUT OF VACUUM PUMP SYSTEM

TYPICAL EXAMPLE

Example in the use of the tables for determining the size of pipe necessary in various parts of the vacuum pump system are shown in the accompanying diagram (Fig. 8):

The equivalent length of run from the source of steam supply *A* to the farthest radiator supplied by any supply main (or the radiator on floor *g* Riser *E*) is between 600 and 800 ft.—therefore size the entire run according to Column *H*, Table 18, observing *Note 4* as regards maximum capacity of up-feed supply risers given in Column *K*.

PART OF SYSTEM	SECTION OF PIPE	RADIATION SUPPLIED, SQ. FT.	PIPE SIZE, INCHES
Riser *E*	*f* to *g*	400	2½
" "	*e* to *f*	600	2½
" "	*d* to *e*	800	3
" "	*c* to *d*	1000	3
" "	*b* to *c*	1200	3½
" "	*a* to *b*	1400	3½
Branch	to Riser *E*	1400	3½
Supply Main	*D* to *E*	1600	3½
" "	*C* to *D*	2400	4
" "	*B* to *C*	3200	5
" "	*A* to *B*	4800	6

The equivalent length of run from the source of steam supply *A* to the farthest radiator supplied by riser *D* is between 500 and 600 ft.—therefore size riser *D* and its branch according to Column *G* observing *Note 4* as regards maximum capacity of up-feed risers given in Column *K*. Note that the maximum allowable capacity of the riser as given in Column *K* and not Column *G*, determines the size of some sections of the riser.

PART OF SYSTEM	SECTION OF PIPE	RADIATION SUPPLIED, SQ. FT.	PIPE SIZE, INCHES
Riser *D*	*f* to *g*	200	2
" "	*e* to *f*	300	2
" "	*d* to *e*	400	2½
" "	*c* to *d*	500	2½
" "	*b* to *c*	600	2½
" "	*a* to *b*	700	3
Branch	to Riser *D*	700	3

Size riser *C* in manner similar to that used for riser *D*.

The equivalent length of run from the source of steam supply *A* to the farthest radiator supplied by main *BF* (or the radiator on floors *g* riser *F*) is between 400 and 500 ft.—therefore size the entire run from *B* to top of riser *F*, according to Column *F*, Table 18, observing *Note 4* as regards maximum capacity of up-feed supply risers given in Column *K*.

PART OF SYSTEM	SECTION OF PIPE	RADIATION SUPPLIED, SQ. FT.	PIPE SIZE, INCHES
Riser *F*	*f* to *g*	400	2½
" "	*e* to *f*	600	2½
" "	*d* to *e*	800	3
" "	*c* to *d*	1000	3
" "	*b* to *c*	1200	3½
" "	*a* to *b*	1400	3½
Branch	to Riser *F*	1400	3½
Main	*B* to *F*	1600	3½

The equivalent length of run from the farthest radiator served by any return main (or that on floor *g* return riser *G*) to the vacuum pump is between 600 and 800 ft.—therefore size entire run according to Column *U*.

PART OF SYSTEM	SECTION OF PIPE	RADIATION SERVED, SQ. FT.	PIPE SIZE, INCHES
Return Riser *G*	*g* to *f*	400	¾
" " "	*f* to *e*	600	¾
" " "	*e* to *d*	800	1
" " "	*d* to *c*	1000	1
" " "	*c* to *b*	1200	1
" " "	*b* to *a*	1400	1¼
Branch	to Return Riser *G*	1400	1½
Return Main	*G* to *H*	1600	1½
" "	*H* to *I*	2400	2
" "	*I* to *J*	3200	2
" "	*J* to *L*	4800	2½

The equivalent length of run from the farthest radiator served by return riser *H* to the vacuum pump *L* is between 500 and 600 ft.—therefore size return riser *H* according to Column *T*.

PART OF SYSTEM	SECTION OF PIPE	RADIATION SERVED, SQ. FT.	PIPE SIZE, INCHES
Return Riser *H*	*g* to *f*	200	¾
" " "	*f* to *e*	300	¾
" " "	*e* to *d*	400	¾
" " "	*d* to *c*	500	¾
" " "	*c* to *b*	600	¾
" " "	*b* to *a*	700	¾
Branch	to Return Riser *H*	700	1

The equivalent length of run from the farthest radiator served by riser *I* to the vacuum pump is between 300 and 400 ft.—therefore size that riser according to Column *R*. Size the return riser *I* in a manner similar to that used for riser *H*.

The equivalent length of run from the farthest radiator served by return main *JK* to the vacuum pump is between 400 and 500 ft.—therefore size entire run from top of return riser *K* to *J* according to Column *S*.

PART OF SYSTEM	SECTION OF PIPE	RADIATION SERVED, SQ. FT.	PIPE SIZE, INCHES
Return Riser *K*	*g* to *f*	400	¾
" " "	*f* to *e*	600	¾
" " "	*e* to *d*	800	1
" " "	*d* to *c*	1000	1
" " "	*c* to *b*	1200	1
" " "	*b* to *a*	1400	1
Branch Return Main	to Return Riser *K*	1400	1¼
	K to *J*	1600	1½

TYPICAL PIPING CONNECTIONS

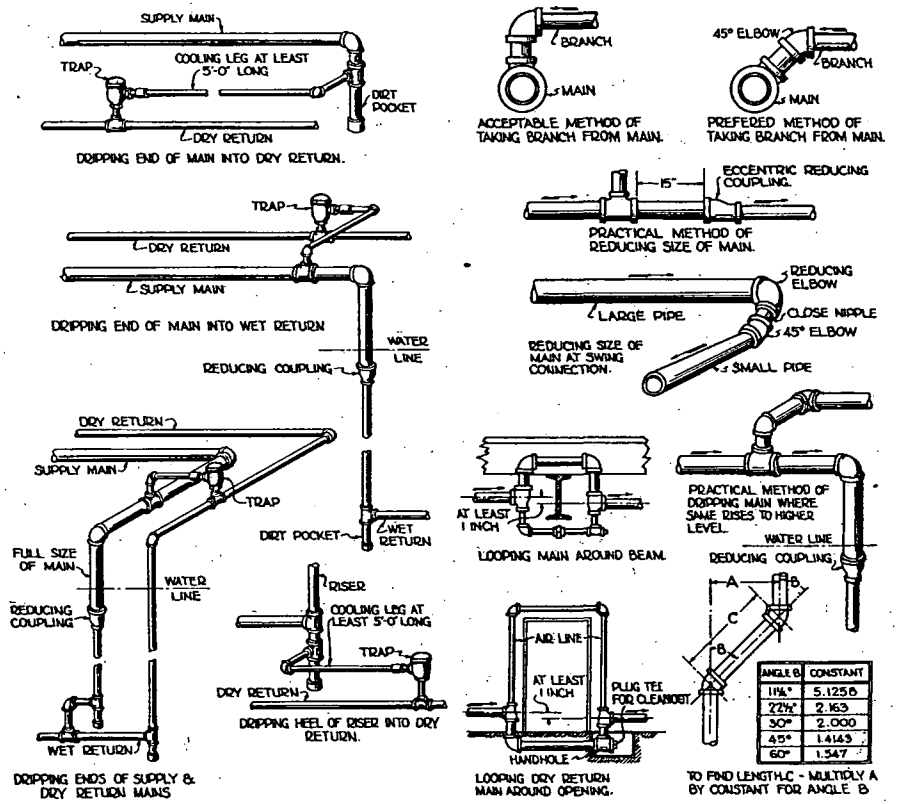


FIG. 9. TYPICAL CONNECTIONS FOR MAINS AND BRANCHES

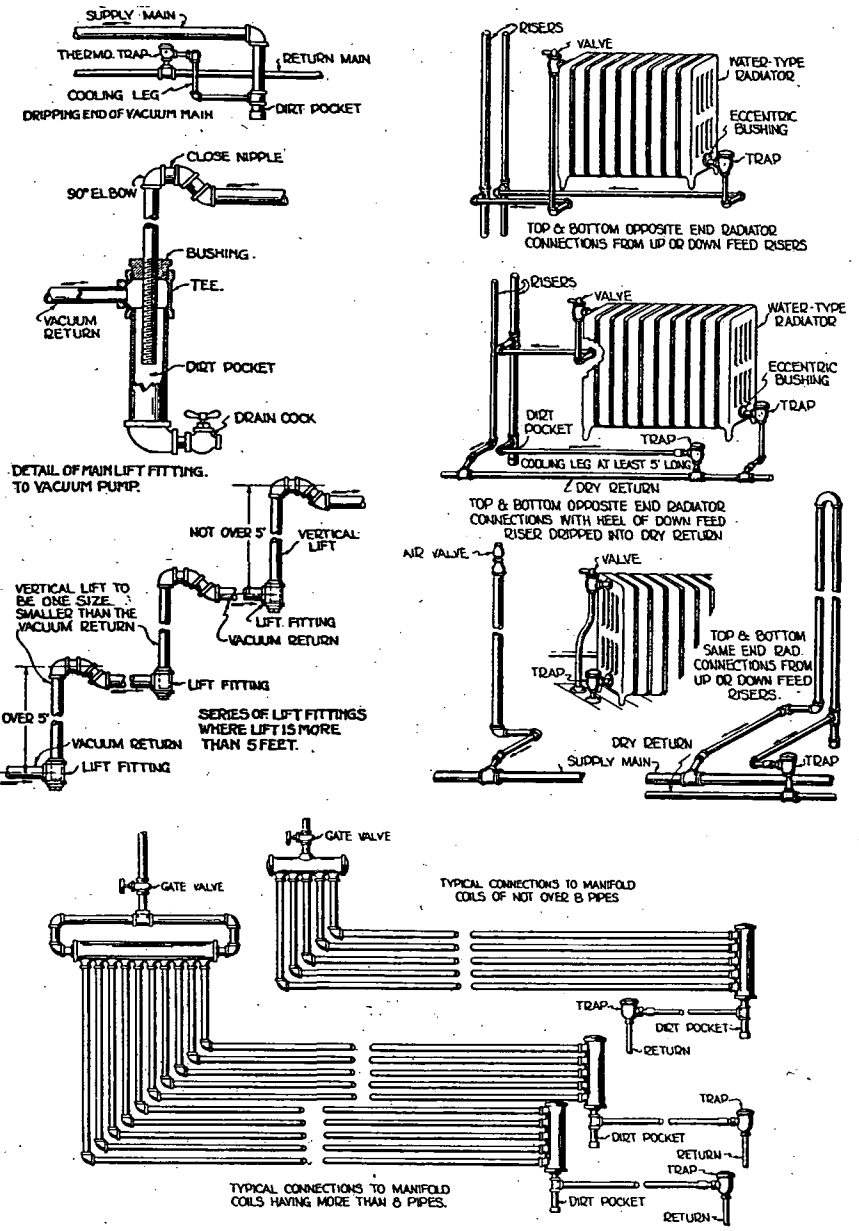


FIG. 10. TYPICAL STEAM PIPING CONNECTIONS

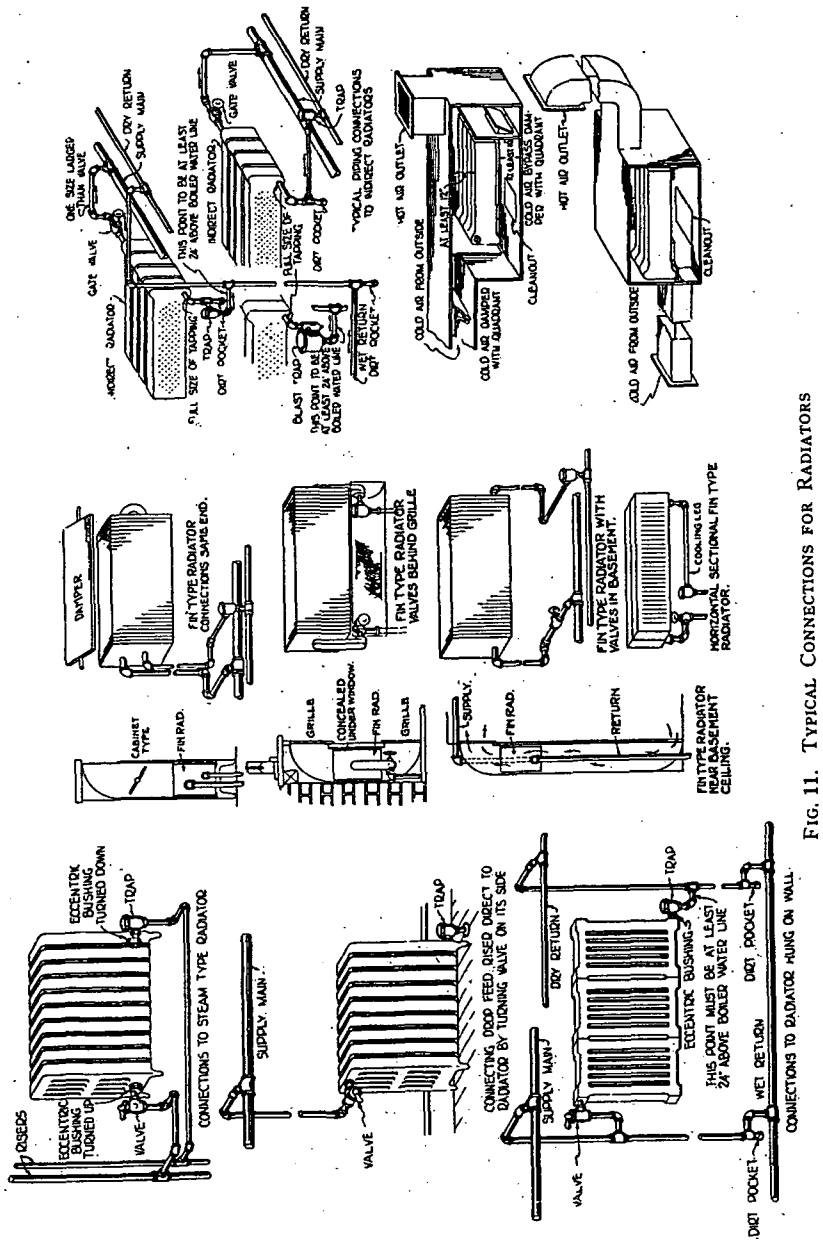


FIG. 11. TYPICAL CONNECTIONS FOR RADIATORS

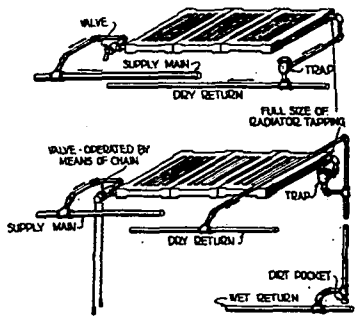


FIG. 12. METHOD OF CONNECTING CEILING RADIATORS

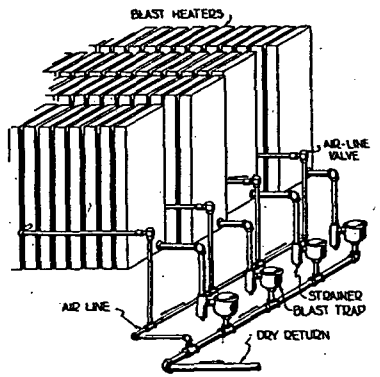


FIG. 13. TYPICAL CONNECTIONS TO BLAST COILS EXCEEDING 12 SECTIONS

Note.—Blast Coils having less than 12 sections—omit air-line and air line valve.

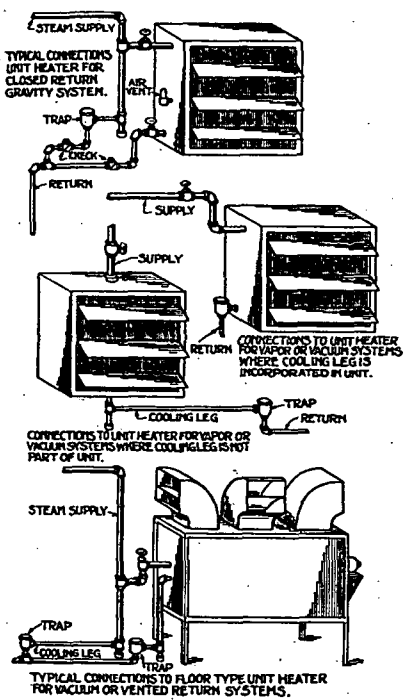


FIG. 14. UNIT HEATER CONNECTIONS

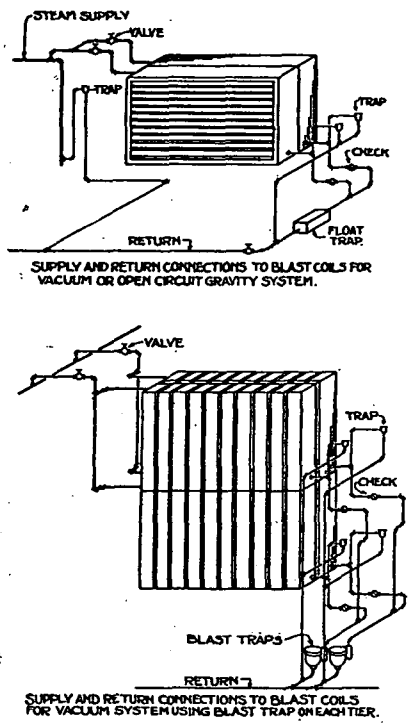


FIG. 15. CONNECTIONS FOR BLAST HEATERS

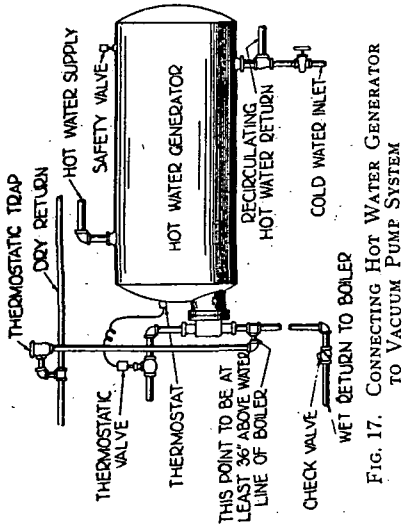


FIG. 17. CONNECTING HOT WATER GENERATOR TO VACUUM PUMP SYSTEM

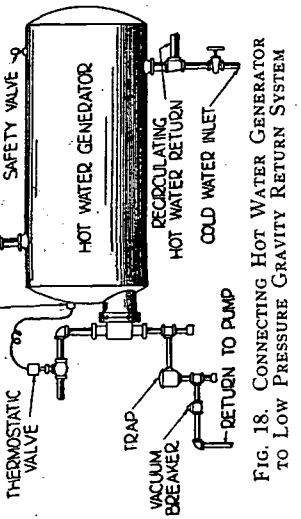


FIG. 18. CONNECTING HOT WATER GENERATOR TO LOW PRESSURE GRAVITY RETURN SYSTEM

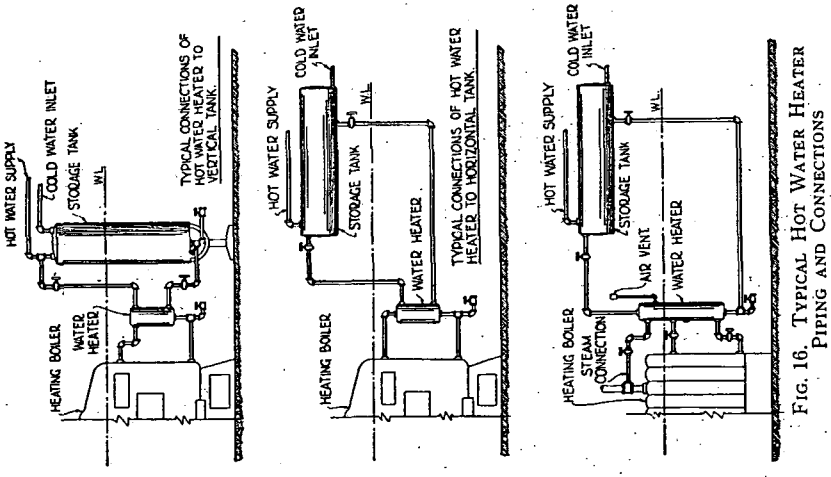


FIG. 16. TYPICAL HOT WATER HEATER PIPING AND CONNECTIONS

CHAPTER IV

HOT WATER HEATING SYSTEMS AND PIPING

Heat Emission of Hot Water Radiators, Temperature Drop, Different kinds of systems, Determination of Pipe Sizes, Simple Rules for Small Systems, Details of Connection.

THE feature which distinguishes hot-water heating systems from all other types is that water serves as the medium by which heat is conveyed from the heater to the radiators. Water has a large capacity for heat and for that reason it is well suited to perform the service of conveying heat.

The design of a hot-water heating system should include the radiators, the heater or heaters, and the piping system. These three subjects will be considered in the order named.

RADIATION

To proportion the radiation it is necessary to know the quantity of heat, *i.e.*, the number of B.t.u. which are lost in a unit of time by the room or space in which the radiator is to be located and which must be replaced by the heat dissipated by the radiator so that the room or space may remain at the desired temperature.

The methods of determining the heat losses from a building or part of a building are explained in Chapter I.

Knowing the number of B.t.u. which a particular radiator is to dissipate (see Chapter II), it is necessary to assume the temperatures at which the water is to enter and to leave the radiator. Having done this, it is customary to assume that the mean of these two temperatures is the average temperature of the water in the radiator. For example, if the water is to enter the radiator at a temperature of 200 deg. and to leave it at a temperature of 180 deg., it is assumed that the average temperature of the water in the radiator is 190 deg. If, in this case, the average room temperature is to be 70 deg., the average difference of the temperature of the water in the radiator and of the air surrounding the radiator is 120 deg. This temperature difference, water to air, is used as the basis for the design of the radiator.

The transfer of heat from the radiator to the surrounding space takes place partly by radiation, partly by convection, and partly by conduction. The quantity of heat dissipated by a radiator per square foot of surface, per hour, and per degree of temperature difference, water to air, is the heat dissipation coefficient of the radiator. This coefficient is generally represented by the letter k. A little reflection will convince the reader that the value of k, for a given type radiator, must decrease as the length

This Chapter especially prepared for THE GUIDE by Prof. F. E. Giesecke, Director of Texas Engineering Experiment Station, College Station, Texas.

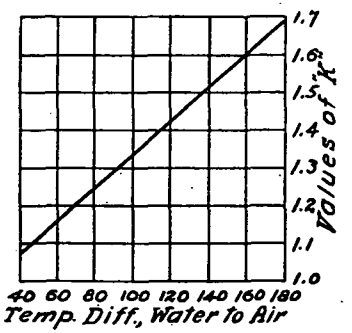


FIG. 1. HEAT DISSIPATION COEFFICIENT—*K*—OF A 38-IN., 3-COL. 20 SEC. HOT WATER RADIATOR AS DETERMINED AT THE UNIVERSITY OF ILLINOIS

of the radiator is increased, as its height is increased, as the number of columns in the radiator are increased, and as the temperature difference, water to air, is decreased. The writer conducted a series of tests in the laboratory of the Department of Mechanical Engineering, University of Illinois, to determine the values of *k* for a 38-in., 3-col., 20-sec. radiator, when the temperature difference, water to air, varied from about 55 deg. to about 145 deg., and when the water entered the radiator through the upper tapping and was discharged through the lower tapping. The results of this series of tests are shown in Fig. 1.

Using the values of Fig. 1 as a basis and assuming that the heat dissipation coefficient of a hot-water radiator varies with the height of the radiator and with the number of columns of the radiator in substantially the same manner in which the heat dissipation coefficient of a steam radiator varies, as determined by Professor Allen and other investigators, Fig. 2 shows the values of *k* for the most common types of hot-water radiators. It can be used to determine the size of the radiator when the type of the radiator to be used, the average temperature difference, water to air, and the quantity of heat to be dissipated per hour by the radiator are known.

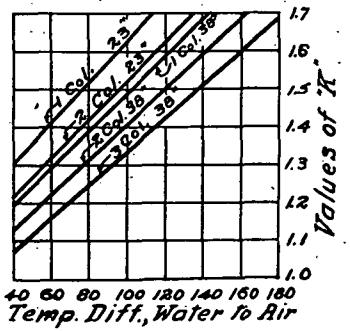


FIG. 2. SUGGESTED VALUES FOR THE HEAT DISSIPATION COEFFICIENTS—*K*—OF VARIOUS TYPES OF HOT WATER RADIATORS

An inspection of Figs. 1 and 2 shows that it is very important to maintain a high average water temperature in every radiator. For example, if a 38-in., 3-col., radiator, located in a room having a temperature of 70 deg., is to dissipate 12,000 B.t.u. per hour, a 100-ft. radiator must be selected if the average water temperature in the radiator is 160 deg., whereas we may use a 70-ft. radiator if the average water temperature is 190 deg., or a 60-ft. radiator if the average water temperature is 205 deg.

It will be shown in the discussion of the design of the pipe system, that a decrease in pipe sizes results in an increase of friction, in an increase in the difference of the temperatures of the water in the flow and return risers, and consequently, in a decrease in the average temperature of the water in the radiator.

It is evident from the preceding discussion of radiator design that any economy which may have been effected by reducing pipe sizes will be offset in part, and may be totally offset, by the increased sizes of the radiators, particularly as the cost of a hot-water heating system is frequently based on the total radiation surface.

To illustrate the use of the diagrams of Fig. 2, let it be required to find the size of the radiator to be used if 8000 B.t.u. are to be dissipated by a 38-in., 3-col. radiator when the average temperature difference, water to air, is 170 − 70, or 100 deg. The value of *k* for this case, from Fig. 2, is about 1.34. The total surface required is 8000/1.34 × 100 or 60 sq. ft.

HEATER

To determine the heater it is necessary to know the quantity of heat which is to be transmitted to the water in the heater, and whether hard coal, soft coal, gas, steam, or electricity is to be used for heating the water.

The engineer designing a hot-water heating system does not, as a rule, design the heater. He simply selects a heater suited to his needs from those available on the market. In selecting a heater for large installations, it is generally desirable to install at least two heaters, so that if one should fail the other will be available. When two heaters are installed, it may be advisable to select them of different sizes, the larger one having a capacity about 75 per cent greater than the smaller heater. If this is done, the heaters should be selected of such sizes that both may be used during extremely cold weather and the smaller or the larger during milder weather, depending on the outside temperature so that, at all times, the heating plant may be operated at a fairly high efficiency. There is frequently an advantage in having the two heaters of the same size so they may be interchangeable. This arrangement is very satisfactory, especially in the colder climates, if each heater is made of a size sufficient to carry about two-thirds of the maximum load.

PIPING SYSTEM DESIGN

To design the piping for a hot-water heating system many factors must be considered. For any given combination of heater and radiator, several different systems of piping may be designed so as to secure successful and satisfactory operation of the system.

There is only one general rule for the design of pipe systems that is applicable in all cases. It is this: *When the heating system is functioning at a uniform rate, that is when, in a given time, the radiators dissipate exactly the same quantity of heat that is delivered to the water in the heater, and when, consequently, the water in the system is circulating with a uniform velocity*, the friction head in every circuit leading from the heater to a radiator and back again must be exactly equal to the pressure head for that particular radiator, *i.e.*, to the pressure head which tends to make the water flow from the heater to that radiator and back again, along the circuit referred to previously.

Before applying this general rule to the design of a piping system, it is necessary to assume:

1. The maximum temperature of the water leaving the heater when the outside temperature is the minimum for which the system is to be designed.
2. The drop in the temperature of the water while it is flowing through the radiator.
3. Whether the circulation of the water in the system is to be effected by gravity or by circulating pumps.
4. The arrangement of the piping connecting the heater with the several radiators.

These four preliminary steps will be discussed in the order named.

MAXIMUM WATER TEMPERATURE

For some time it has been customary to select 180 deg. as the maximum temperature of the water leaving the heater. With this maximum temperature and a temperature drop of 20 deg. through the radiator, the average water temperature in the radiator will be 170 deg. If the temperature of the room is to be 70 deg., the temperature difference, water to air, will be 100 deg. The corresponding value of k for a 38-in., 3-col. radiator is 1.34 and the heat dissipated by the radiator per square foot per hour is 134 B.t.u. A steam radiator of similar size and design and supplied with low-pressure steam will dissipate about 210 B.t.u. per square foot an hour. Under these conditions, a hot-water heating system would require about 210 sq. ft. of radiation for every 134 sq. ft. required by the steam heating system. The first cost of the hot-water system would, consequently, be considerably higher than that of the corresponding steam system. This higher first cost of a hot-water system is frequently the cause of the installation of a steam system.

If, on the other hand, 220 deg. is selected as the temperature of the water leaving the heater, the average temperature of the water in the radiator will be about 210 deg., practically the same as that in low-pressure steam radiation, and the total radiation required for the hot-water system will be about the same as that required for the corresponding steam system. The cost of the pipe system for hot water is probably a little higher than the cost of the pipe system for steam, but the cost of valves and traps for a steam system is higher than the cost of the valves for a hot-water system, so that, finally, the cost of a hot-water heating system will not be higher, and is frequently lower, than the cost of a corresponding steam heating system, if the maximum temperature of the water is selected sufficiently high.

The selection of 220 deg. as the maximum water temperature is entirely proper because the minimum outside temperature for which the

heating system is designed and for which the heat losses are calculated, occurs only a few times in any one year and perhaps never in some years. Consequently, it is very seldom and in some years never necessary to heat the water to the assumed maximum temperature.

If 220 deg. is selected as the maximum temperature, it is necessary to provide sufficient pressure of the water in all radiators and in the entire pipe system so that the water will not boil at that temperature. This can be accomplished easily in all closed systems and also in all open systems. In the latter case, it is only necessary to place the expansion tank at a sufficient altitude above the highest point of the heating system. For example, if the expansion tank is located 10 ft. above the highest point in the system and if the expansion tank riser is filled with 200 deg.

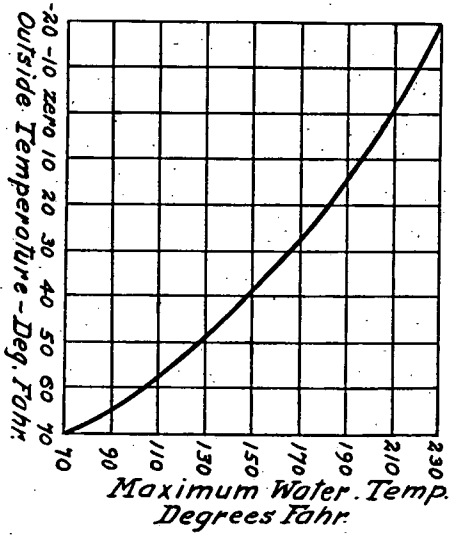


FIG. 3. AN ILLUSTRATION OF THE VARIATION, WITH THE OUTSIDE TEMPERATURE, OF THE REQUIRED MAXIMUM WATER TEMPERATURE IN THE HEATING SYSTEM

water when the flow risers carry 220 deg. water, the pressure at the highest point of the heating system will be about 4.2 lb. per sq. in. The corresponding boiling point is about 226 deg. and there would be no danger of boiling the water in the heating system at 220 deg.

In such cases the expansion tank riser should be connected to the return main. Precautions must always be taken to prevent freezing of the water in the expansion tank or in the expansion tank riser.

Having assumed the maximum temperature of the water for the minimum outside temperature, the required maximum temperature of the water for any other outside temperature may be found as follows:

If 220 deg. is selected as the maximum temperature of the water when the minimum outside temperature is -10 deg., if the inside temperature is to be 70 deg. and the temperature drop through the radiator is to be 20 deg., if R represents the total radiation in square feet, and if

it is assumed that the total heat losses are proportional to the temperature differences, inside and outside, the total heat loss will be 1.52 R (210 − 70) or 212.8 R. In this calculation, 1.52 is the value of k for a 38-in., 3-col. radiator. When the maximum water temperature is 180 deg., the total heat loss will be 1.34 R (170 − 70) or 134 R. Similarly, when the maximum water temperature is 140 deg. the total heat loss will be 69.6 R. Since a heat loss of 212.8 R corresponds to a temperature difference, inside to outside, of 80 deg., heat losses of 134 R and 69.6 R, correspond, respectively, to 49 deg. and 25.5 deg. of temperature differences. Consequently, the two assumed maximum water temperatures correspond, respectively, to outside temperatures of 21 deg. and 44.5 deg. From such data, a curve like that shown in Fig. 3 may be constructed and used to determine the maximum water temperature for any given outside temperature.

Such a curve will, however, not show the correct water temperatures for all times, as heat loss of buildings depends to a large extent upon the direction and velocity of the wind. The values shown by the curve must, therefore, be modified from time to time by the operating engineer according to the character of the wind prevailing at that particular time.

TEMPERATURE DROP THROUGH THE RADIATOR

For any given radiator, the drop in the temperature of the water as it flows through the radiator is determined by the quantity of water flowing through the radiator in a given time. For example, if a radiator is to dissipate 10,000 B.t.u. per hour with a temperature drop of 10 deg., it is necessary that 1000 lb. of water flow through the radiator per hour. If, on the other hand, the temperature drop is to be 20 deg., only 500 lb. of water must flow through the radiator per hour. If, in both cases, the same size pipe is used, the velocity of the water must be twice as high in the former case as in the latter, and since the friction of water in pipes varies almost as the square of the velocity, it follows that the friction head is almost four times as great in the former case as in the latter. If, in both cases, the friction head must have a fixed value—the same as that of the available pressure head, it is evident that the temperature drop through the radiator decreases as the pipe sizes are increased. It was shown above that the required size of the radiator decreases as the temperature drop through the radiator decreases.

Reducing the temperature drop through the radiator, then, decreases the sizes of the radiators but increases the sizes of the piping; in other words, it decreases the cost of the radiators but increases the cost of the piping. There is, consequently, an optimum temperature drop through the radiators for every installation which carries with it the lowest cost of installation. This optimum temperature drop can be determined by a few trial calculations. As a rule, such calculations are never made; the temperature drop is selected arbitrarily.

A temperature drop of from 20 to 30 deg. is common and generally quite satisfactory.

THE MOTIVE FORCE

Whether gravity circulation or forced circulation is to be adopted for any particular installation is generally evident from the nature of the case.

In almost all residence systems and in a good many installations in

larger buildings, gravity circulation is entirely satisfactory and should be adopted because its operation is much more simple and also cheaper than that of forced circulation.

For installations which are too large to function well as gravity systems and for all general heating systems which serve a group of buildings, forced circulation should be adopted.

The optimum velocity of the water in forced circulation systems is subject to calculation. As the velocity is increased, the size, and therefore also the cost, of the piping and radiation is decreased but the cost of the pump and the cost of operating the pump are increased. As a general rule, a velocity of from 6 to 10 ft. per second will be found satisfactory.

In gravity circulation systems, the velocity of the water generally varies from about 1 to about 6 in. per second.

ARRANGEMENT OF PIPING

Having determined the location of the heater and the locations of the several radiators, there are a large number of different ways in which the piping can be arranged to connect the heater and the radiators so as to secure an entirely satisfactory operation of the system, provided the radiators and the several pipes of the system are of correct size so that, in every case, the pressure head for every radiator is exactly equal to the friction head in the circuit of that radiator, when the system is operating at a uniform rate and when each radiator is dissipating its correct quantity of heat.

Fig. 4 shows a very small heating system consisting of a heater, located in the basement, two radiators on the first floor, and two on the second floor. Ten different methods of connecting the heater to the radiator for this small system are shown. It is evident that the ten methods shown are not the only methods which could be used. It is also evident that for a larger heating system, a larger number of different methods of connecting the heater to the radiators exist.

Several attempts have been made to assign distinctive names to the several methods or types of piping for hot-water heating systems. The result is not satisfactory because it is possible to have so many variations of each typical method or system of piping. The following definitions, supplemented by the illustrations of Fig. 4, will serve to describe the more common general types of piping:

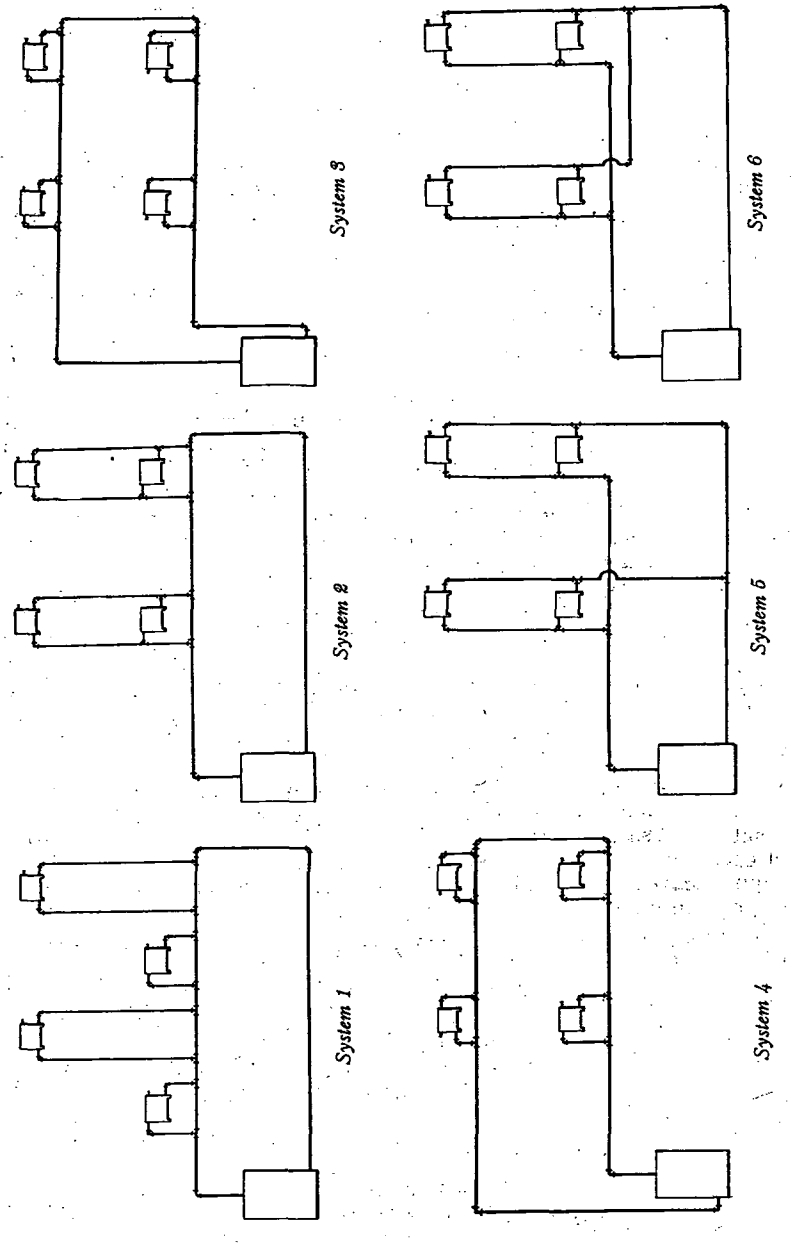
1. A *one-pipe* system is one in which the water flows through more than one radiator before it returns to the heater.

2. A *two-pipe* system is one in which all water returns to the heater after it has passed through one radiator. In a two-pipe system all radiators are supplied with water at the temperature at which the water leaves the heater, neglecting the slight cooling which takes place in the pipe leading from the heater to the radiator.

Systems 1, 2, 3, and 4 of Fig. 4 have one-pipe mains and two-pipe risers. Systems 7 and 8 have two-pipe mains and one-pipe riser. Systems 5, 6, 9, and 10 have two-pipe systems throughout.

3. An *over-head* distribution system is one in which a main flow riser extends from the heater to the attic, the distributing main is located in the attic, and the return main in the basement. Systems 7, 8, 9, and 10 illustrate this type.

4. An *under-foot* distribution system is one in which the main flow riser extends only to the basement ceiling, and the main flow line as well as the main return line is located below the basement ceiling. Systems 1, 2, 3, 4, 5, and 6 illustrate this type.



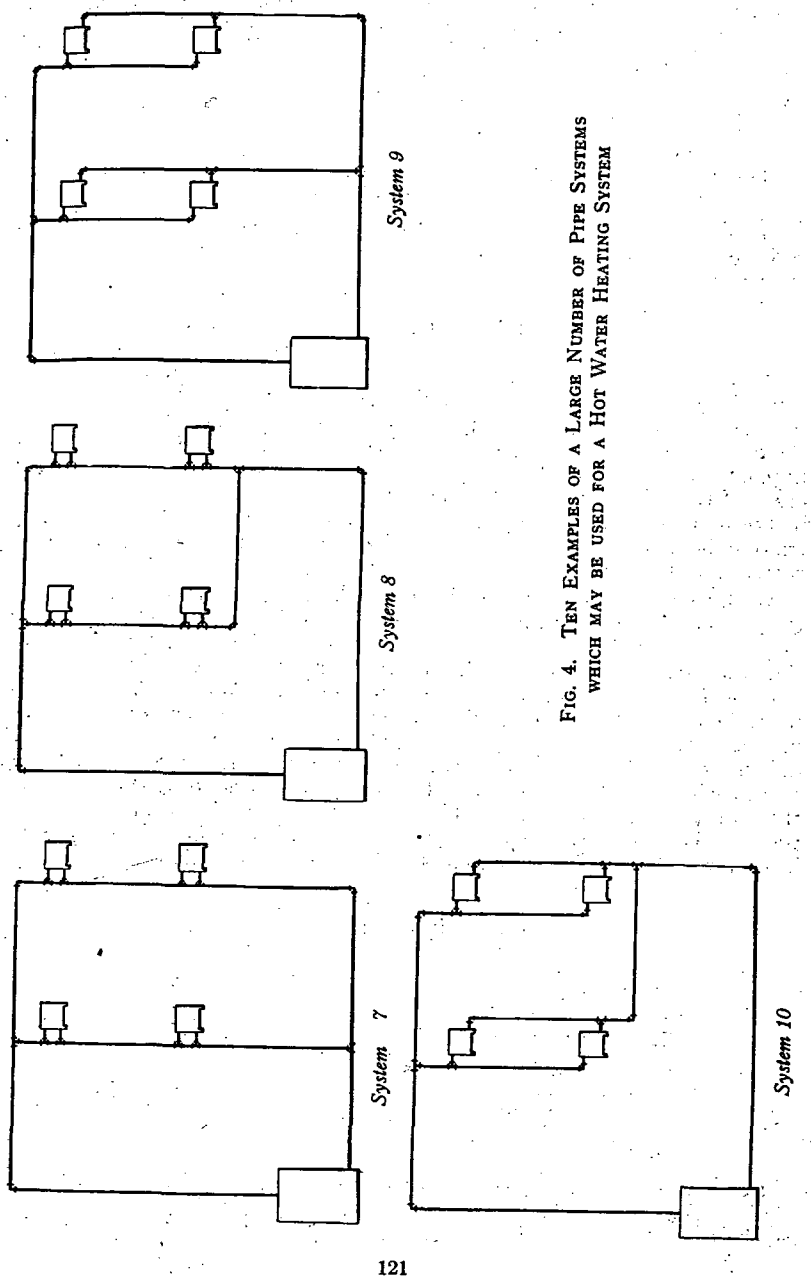


Fig. 4. Ten Examples of a Large Number of Pipe Systems which may be used for a Hot Water Heating System

5. A *direct-return* system is one in which the water is returned to the heater along a direct path, so that the total distance traveled by the water is the shortest feasible distance, and so that there is a considerable difference in the lengths of the several circuits composing the system.

6. A *reversed-return* system is one in which the water from the several radiators is returned along paths arranged so that all circuits composing the system, or composing major sub-division of the system, are practically of equal length. A reversed-return system is to be preferred to a direct-return system because it is easier to arrange the circuits so that, in every case, the friction head is equal to the pressure head, and because, in starting the system, all circuits of the reversed-return system being to function practically at the same time, whereas, in a direct-return system, the longer circuits require considerably more time to begin operating than the shorter circuits. The direct-return system is illustrated by Systems 5, 7, and 9. The reversed-return system is illustrated by Systems 6, 8, and 10.

DETERMINING PIPE SIZES

Having settled on the arrangement of the circuits for the system, generally by selecting a scheme similar to one of those shown in Fig. 4, it is customary to assume the pipe sizes and, having done that, to calculate the pressure head and the friction head for every circuit. If the two heads happen to be practically equal, the assumed pipe size is the correct one. If there is a material difference between the two, a change is made in the assumed size of the pipe, or of a portion of the pipe, and a new friction head calculation is made. This process is repeated until the correct size has been found.

To illustrate the method, let it be required to find the correct size for the pipe of the elementary system shown in Fig. 5. This system is to dissipate 12,000 B.t.u. when the temperature of the water is 200 deg. in the flow riser and 180 deg. in the return riser. The center of the radiator is to be 7 ft. above the center of the heater. The pressure head results from the difference in the weights of two columns of water, 7 ft. high, one having a temperature of 200 deg. and the other one of 180 deg. This difference in weight can be calculated. However, it can be determined more easily from the diagram of Fig. 6. It appears from this diagram that for 200 deg. in the flow riser and 180 deg. in the return riser, the pressure head is 90 milinches per foot of water column. The pressure head for the system is, therefore, 7 × 90, or 630 milinches of water.

TABLE 1. ELBOW EQUIVALENTS

1 90 deg. elbow	1.0
1 45 deg. elbow	0.7
1 90 deg. long turn elbow	0.5
1 Open return bend	1.0
1 Tee	2.2
1 Open gate valve	0.5
1 Open globe valve	12.0
1 Angle radiator valve	2.0
1 Radiator	3.0
1 Heater	3.0

These relations are very nearly correct for the low velocities existing in gravity circulation; for the higher velocities employed in forced circulation, they are sufficiently accurate because every radiator has practically the same number of valves and tees in its circuit and is, therefore, affected equally by any variation from the ratios given above.

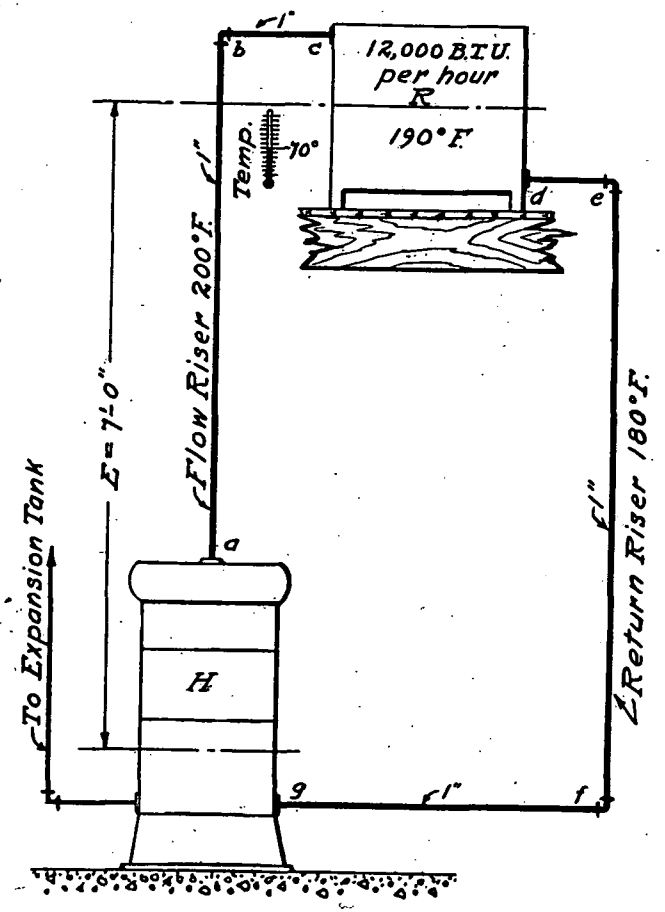


FIG. 5. AN ELEMENTARY HEATING SYSTEM

In other words, the pressure head causing circulation in the system is the same as that produced by a column of water 5/8 in. high.

This calculation shows clearly that the motive force involved in gravity circulation hot-water heating is very small and that great care must be taken to adjust the friction heads to the pressure heads when the water can flow along any one of several available circuits.

To calculate the friction head in the circuit, we note, first, that the circuit consists of 22 ft. of pipe, 3 elbows, 1 heater, and 1 radiator; and, second, from Table 1, that the frictional resistance of 1 heater and 1 radiator is, for each, equivalent to the frictional resistance of 3 elbows. Consequently, the friction head of the entire circuit is equal to that in 22 ft. of pipe and 9 elbows. Assuming, now, that 1-in. pipe is to be used,

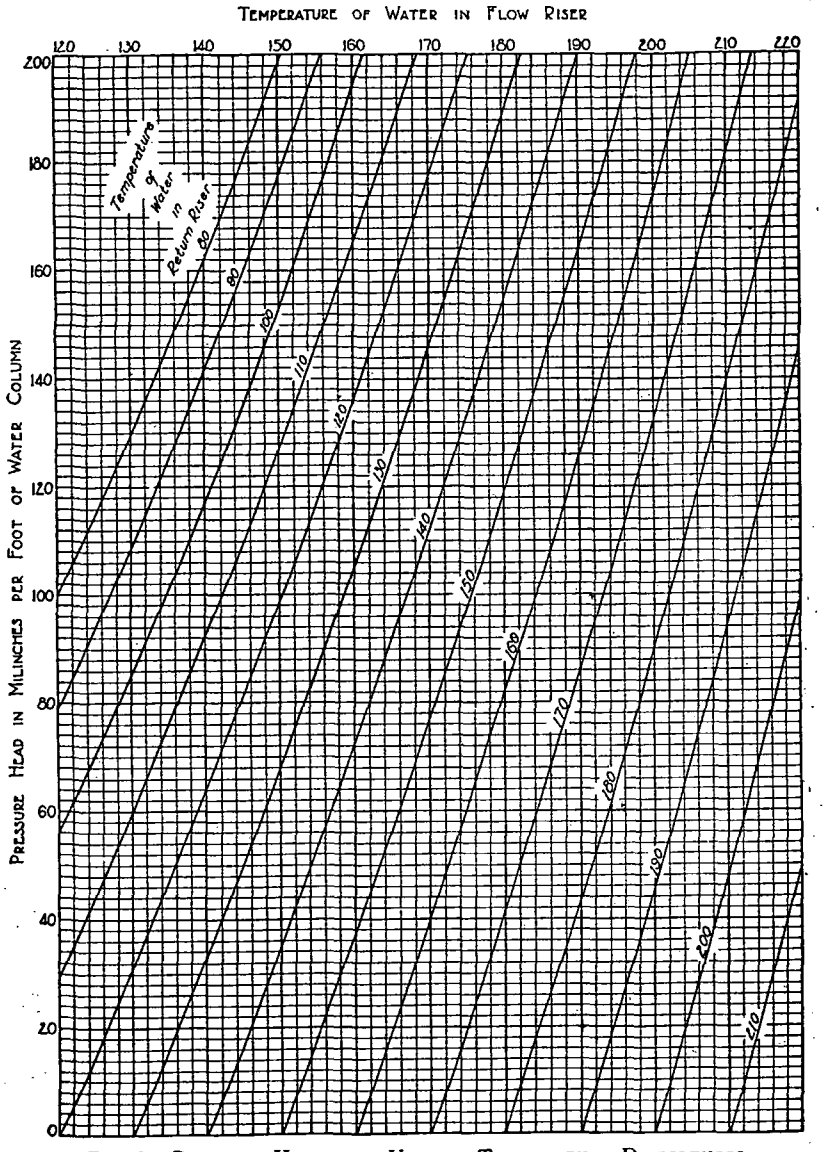


Fig. 6. Pressure Heads for Various Temperature Differences

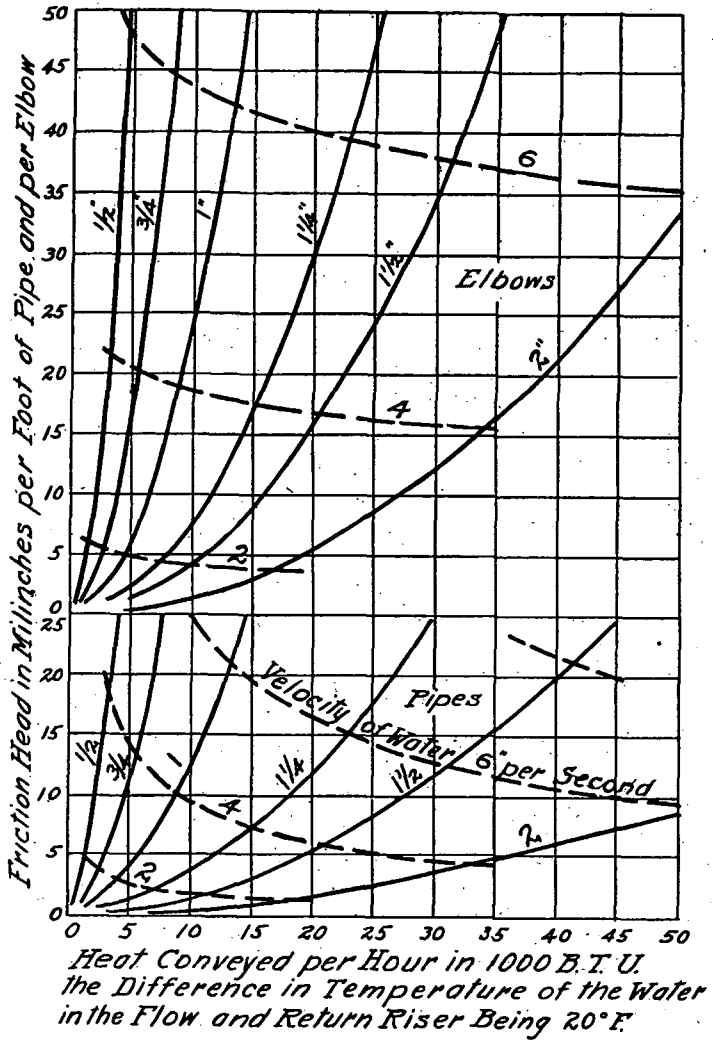


Fig. 7. Friction Heads, in Pipes and Elbows, for a 20 deg. Temperature Difference of the Water in the Flow and Return Lines

the friction heads in the pipe and in the elbows can be calculated by known formulae, or, they can be determined more readily from the diagrams of Figs. 7 and 8. It will be noted from Fig. 7, that for a 1-in. pipe, for 12,000 B.t.u. per hour, and for a temperature drop of 20 deg., the friction head is 18 milinches per foot of pipe and 35 milinches

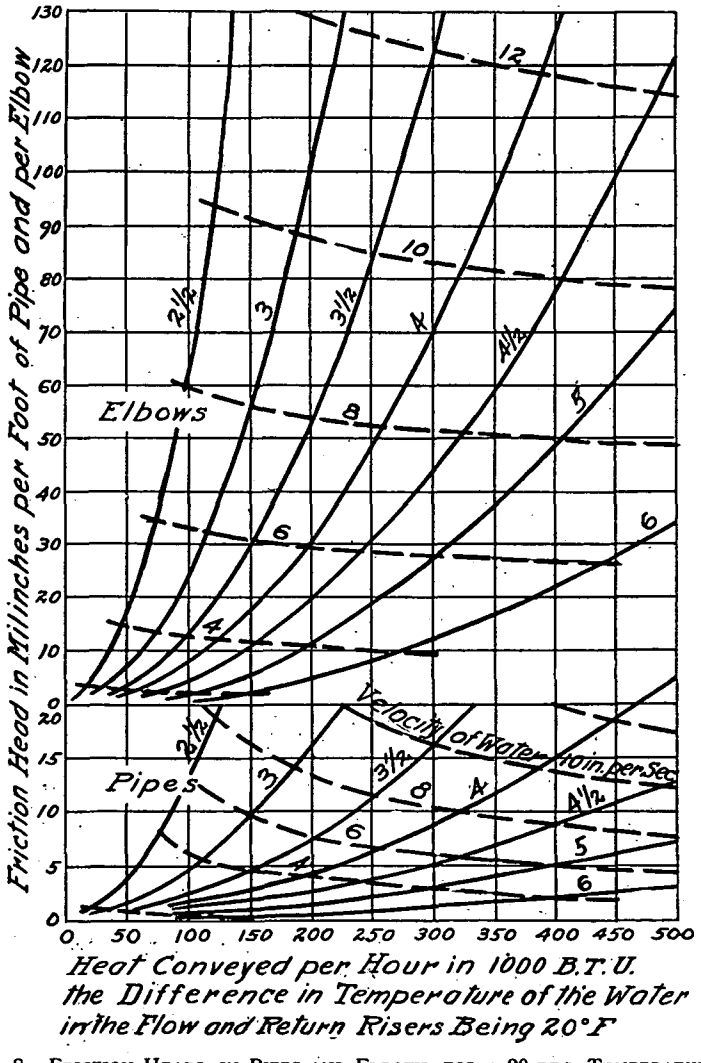


FIG. 8. FRICTION HEADS, IN PIPES AND ELBOWS, FOR A 20 DEG. TEMPERATURE DIFFERENCE OF THE WATER IN THE FLOW AND RETURN LINES

per elbow. Incidentally, we note also that the velocity will be about 5 in. per second.

The total friction is, therefore,

$$22 \times 18 = 396$$
$$9 \times 35 = 315 \quad 711 \text{ milinches.}$$

As this is slightly more than the available pressure head of 630 milinches, a 1-in. pipe is a trifle too small. However, the difference between the calculated friction head and the available pressure head is so small that the 1-in. pipe can safely be used.

If a 1¼-in. pipe were used, the pressure head would be

$$22 \times 5 = 110$$
$$9 \times 11 = 99 \quad 209 \text{ milinches, or less}$$

than one-third of the available pressure head. Consequently, a 1¼-in. pipe would be entirely too large.

The calculation shows how easily friction head calculations can be made. For more complicated installations, the calculations are more complicated, but in all cases, they are fairly simple. More detailed instructions than can be given here for such calculations may be found in textbooks and in magazine articles.

EMPIRICAL RULES

A very great demand exists for empirical rules or tables by means of which pipe sizes for hot-water heating systems can be determined according to the radiation which the pipe is to serve and without the necessity of friction head and pressure head calculations.

It is not possible to prepare such tables or rules which would have any degree of accuracy.

For example, in the elementary heating system shown in Fig. 5, a 1-in. pipe is practically the correct size. If the radiator were placed about 10 or 14 ft. above the heater instead of 7 ft., a 1-in. pipe would be entirely too large; or, if the radiator were placed at a considerably greater distance from the heater so that the number of elbows and the length of the pipe of the circuit were increased materially, a 1-in. pipe would be too small. So in this simple case, under different circumstances, a ¾-in. pipe, a 1-in. pipe, or a 1¼-in. pipe would be the correct size to select. In the 10 types of pipe systems shown in Fig. 4, it is quite evident that no empirical rule could be devised which would correctly give the pipe sizes to be used in every one of the ten cases shown there.

There are a number of empirical rules, however, contained in the catalogue data of the various manufacturers of hot-water heating apparatus which may be used with success if properly applied to such ordinary problems as these manufacturers have found them applicable to. Where the runs are not long and the various branches of the system can be fairly well equalized as to length of run and amounts of radiation, these practical rules, when applied to residences and other relatively small buildings of ordinary ceiling lengths, prove quite successful.

There are also a number of practical suggestions, to be found in these data, as to piping details and different kinds of connections.

GRAVITY HOT WATER HEATING[1] FOR SMALLER INSTALLATIONS

In the average small hot-water heating system such as is used for bungalows, cottages and even the modest sized home or residence, it is

[1]Compiled by H. L. Alt, Philadelphia.

TABLE 2. AREAS OF STANDARD SIZE PIPES OF STANDARD WEIGHT

Nominal Size of Pipe Inches	Area of Pipe Sq. In.
⅜	0.192
½	0.305
¾	0.533
1	0.863
1¼	1.496
1½	2.038
2	3.356
2½	4.784
3	7.388
3½	9.887
4	12.73
5	19.99
6	28.89
8	50.04
10	78.84
12	113.10

not usually the case to find much attention given to complicated formulae and curves; this is for the reason that the saving on installations involving only a few hundred dollars is so small as not to justify elaborate engineering calculation besides which the work itself is generally installed by a competition contractor and no funds are available for which a proper designer could be employed. As a general rule the contractor himself does all the designing which is necessary and he doesn't want to be bothered with any complication which can in any way be avoided.

Probably the simplest way of determining hot-water pipe sizes in the ordinary small gravity system is the old method of taking the area of each radiator connection or valve and adding these areas together where the lines join, making the area of combined line practically equal to the sum of all the areas which the line supplies.

Thus if a pipe is feeding three radiators, one with a ¾-in. connection, one with a 1-in. connection and the third with a 1½-in. connection the sum of these areas is as follows:

1 in.	0.863 sq. in.
1½ in.	2.038
¾ in.	0.533
	3.434 sq. in.

Referring back to the table it will be found that the pipe which has practically the same area is a 2-in. pipe which has an area of 3.356 sq. in.

For jobs of somewhat larger character where too much refinement is

TABLE 3. SQUARE FEET OF RADIATION ALLOWABLE ON RISERS UP TO 100 FT. HEIGHT

Nominal Pipe Size Inches	Distance above the Boiler in Feet									
	10	20	30	40	50	60	70	80	90	100
¾	40	50	60	70	80	90	100	110	120	130
1	70	80	90	100	110	120	130	140	150	160
1¼	110	120	135	150	160	175	185	200	210	225
1½	180	185	210	230	250	265	285	300	315	330
2	300	350	400	500	575	625	700	775	825	900

unnecessary but at the same time closer results than that given in the above are desired, the table given below which takes into the consideration the height of the riser available to circulate the line may be recommended.

The risers are then connected up to the mains on the basis of allowing a factor for each size of pipe and then adding these factors to obtain the factor corresponding to the proper size of basement main. These factors are as follows:

TABLE 4. FACTORS FOR VARIOUS SIZES OF PIPE IN GRAVITY HOT WATER HEATING

Nominal Size of Pipe Inches	Factor
¾	5
1	10
1¼	20
1½	30
2	60
2½	110
3	175
3½	260
4	380
5	650
6	1050
8	2250
10	.....
12	.....

Thus, if the three radiators previously considered were set and sized as follows; the ¾-in. radiator with 20 sq. ft., and located 40 ft. above the boiler; the 1-in. radiator with 40 sq. ft. and set 20 ft. above the boiler and the 1½-in. radiator with 75 sq. ft., and set 10 ft. above the boiler all being on the same riser, the riser size would be as follows:

Riser for 20 sq. ft. radiator 40 ft. above	¾ in.
Riser for 40 sq. ft. radiator 20 ft. above	¾ in.
Riser for 75 sq. ft. radiator 10 ft. above	1¼ in.

To combine into one riser take the factors and add;

¾ in.	5 factor
¾ in.	5
1¼ in.	20
Total	30

and the factor 30 is equivalent to a 1½-in. riser.

Even if these radiators had all been placed on the first floor (or 10 ft. above the boiler), the riser size of 1½-in. would still have been sufficient for the three or their equivalent in one radiator. This indicates that the method of combining valve areas gives about one pipe size larger than when more accurately figured.

AIR SEALED OR CLOSED HOT WATER SYSTEMS[2]

For many years the closed system of hot-water heating in some form has been used successfully abroad, but there has been little thought given to and no research work done in connection with the air sealed system in this country, so that available data is meagre. For design

[2]Prepared from data submitted by R. H. Feltwell, Philadelphia and H. A. Thrush, Peru, Ind.

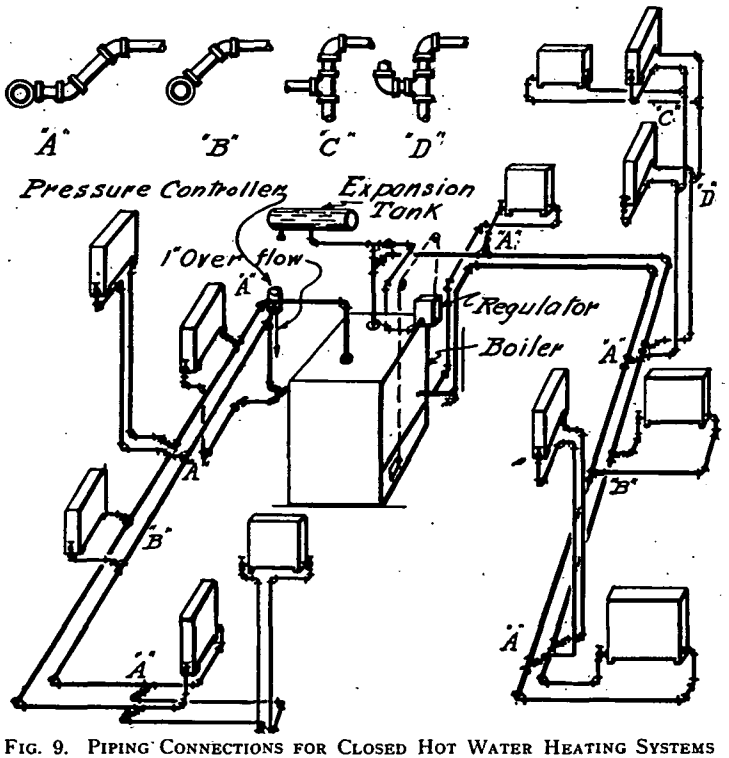


FIG. 9. PIPING CONNECTIONS FOR CLOSED HOT WATER HEATING SYSTEMS

work the engineer, architect or heating contractor, finds little on pipe sizes, etc.

Due to the more rapid circulation of water in an air sealed system 50 per cent more radiation can be supplied than by a gravity connection. Therefore the rules as set forth by F. E. Giesecke, N. S. Thompson and C. A. Fuller in their books on hot-water heating can be used to advantage by adding 50 per cent to their formula for house heating. The following table would then be applicable for air sealed hot-water system.

TABLE 5. PIPE SIZES AND CONNECTIONS FOR CLOSED SYSTEMS

Amount of Radiating

PIPE SIZE INCHES	FIRST FLOOR	SECOND FLOOR	THIRD FLOOR	FOURTH FLOOR
½	30	40	50	60
¾	60	75	90	110
1	110	120	135	150
1¼	165	180	200	225
1½	270	290	315	350
2	450	525	600	750

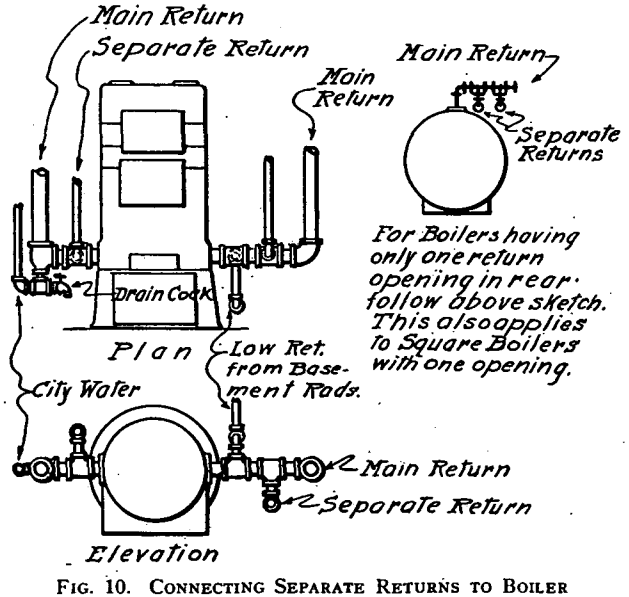


FIG. 10. CONNECTING SEPARATE RETURNS TO BOILER

The piping layout should be designed to conform to the best engineering experience of the engineer. It is not necessary except on very small mains to continue the mains full size to the end for they should end two sizes larger than the last radiator they supply. In all cases mains should end in the first floor radiator. Where a riser extends beyond the last first floor radiator the line running out to it should be treated as a lateral. See plan Fig. 9.

In each case the lateral leading from the main need be no larger than the radiator valve it supplies but care should be exercised that allowance is made for the proper distribution of the water to the radiators. Connections as shown in plan Fig. 9 are recommended, the *B* connection being used on all first floor radiators except right at the boiler where the *A* connection can often be used to advantage. The *C* connection is used on upper floors on the same level to supply two or more radiators from one riser and the *D* connection is used on risers feeding more than one floor and the style of connection should be used on the different floors of a building where it is desired to extend to a floor above.

The area of mains both flow and return must equal or exceed the total area of the valve sizes they are to supply. It is recommended that nearby radiators to the boiler have separate returns and that these returns enter the boiler as shown in Fig. 10.

Many sealed systems of hot-water heating do not function properly on account of lack of air in the air sealed expansion tank. Tank sizes should conform to the amount of water contained in the heating system, and are based on 12½ lb. of water to the gallon, for tank capacity. The

makers of air sealed tank in basement equipment furnish tank sizes for the different amounts of radiation as follows:

Square Feet of Radiation	Gallons	Square Feet of Radiation	Gallons
250 to 350	18	1400 to 1600	54
350 to 450	21	1600 to 1800	60
450 to 650	24	1800 to 2000	70
650 to 900	30	2000 to 2400	80
900 to 1100	35	2400 to 2800	90
1100 to 1400	40	2800 to 3000	110
		3000 to 3500	120

By using the sealed system of hot-water heating it has been found that there is a ready absorption of heat by the water, a rapid circulation and uniform distribution of the water in the radiator and the possibility of close regulation depending on the use of the pressure obtained by the expanding water against the air in the sealed tank. The pressures obtained for different temperatures when tank capacities are as outlined are as follows:

Outside Temperature	Temperature of Water Required to Heat Building	Approximate Position of the Hand on Pressure Gage
60 deg.	100 deg.	At the static head required to fill the system.
50 deg.	120 deg.	1 lb. pressure above static head.
32 deg.	140 deg.	2 lb. pressure above static head.
20 deg.	150 deg.	3 lb. pressure above static head.
15 deg.	160 deg.	4 lb. pressure above static head.
10 deg.	170 deg.	5 lb. pressure above static head.
0 deg.	180 deg.	6 lb. pressure above static head.
−10 deg.	190 deg.	7 lb. pressure above static head.
−20 deg.	200 deg.	8 lb. pressure above static head.
−25 deg.	210 deg.	9 lb. pressure above static head.
−30 deg.	220 deg.	10 lb. pressure above static head.

The table also gives the outside temperature and the corresponding boiler temperature of the water in the radiators necessary to warm to 70 deg., when radiation is figured on the basis of heating rooms to 70 deg.

CHAPTER V

HEATING BOILERS

Duty of Boiler, Boiler Selection, Boiler Ratings, Types of Boilers, Boiler Troubles, Operating Conditions, Burning Anthracite and Bituminous Coal, Pick-up Load, Hot Water Supply Boilers.

IT is important that the duty of the boiler be clearly understood. The boiler accomplishes its main purpose when a specified quantity of heat in dry steam or hot water is delivered at its outlet. If the boiler is equipped with automatic temperature or pressure control, this control should actuate dampers or other means for controlling the rate of combustion within certain limits. When equipped with devices intended to accomplish a certain combustion result, as, for example, to burn bituminous coal smokelessly, such results should be accomplished without undue attention.

Certain conditions affecting the operation of the boiler must be met if it is to accomplish its purpose. The most important of these are as follows:

(1) There must be chimney or other means capable of supplying an adequate draft. (2) The fuel used must be as good as that contemplated when the boiler was selected. (3) The quality and frequency of attention must equal that upon which selection was based. (4) The system must be properly designed to quickly return the water to the boiler after its heat has been delivered to the desired points. (5) Dirt and grease must be kept from the system, leaving reasonably clean water.

BOILER SELECTION

Ordinarily, especially in residence heating and small installations, the information upon which the boiler is selected is very meager. This information usually consists of: the heat output of radiators under normal temperatures, the kind of fuel, whether anthracite or bituminous coal, oil or gas, and in a few cases the amount of piping. Selection of a boiler upon this information is largely guesswork based upon experience, with the result that the boiler is selected large enough to deliver the required quantity of heat under even the most adverse conditions. Boilers having large output and rapid pick-up are frequently selected in preference to boilers having more economical performance.

A proper heating boiler specification would contain the information given in the following items:

1. Maximum hourly output required during "pick-up" period which is made up of the following items: (*a*) The heat output of radiators and other heating units when

---

The material for this Chapter was prepared especially for THE GUIDE by the following committee: Carl H. Flink, *chairman*; A. E. Bastedo, C. E. Bronson, D. S. Jacobus, Alfred Kellogg, P. Nicholls, O. O. Oaks, C. W. Obert and A. L. Sanford.

surrounding air temperatures are normal, and of air heaters when fully heated and in stable operating conditions, (*b*) The heat loss from piping when surrounding air temperatures are normal, (*c*) The heat required to raise temperature of metal in boiler and system to temperature of circulating medium, (*d*) The heat required to raise circulating medium from lowest expected temperature to normal circulating temperature, (*e*) The excess heat output of radiation, other heating units, air heaters and piping due to decreased temperature of surrounding air, (*f*) The heat requirement of attached water heaters and other devices which may require heat during pick-up period. When the system and air have reached normal temperature parts (*c*), (*d*) and (*e*) disappear.

2. The number of hours during which maximum hourly output would be required during heating-up period, which varies according to the use of the building in which the installation is made, usually from 1 to 4 hours, being shortest for residences and longest for buildings used only occasionally.

3. The maximum hourly continuous output for any 24-hour period, or the average output which the boiler would have to deliver during a period of continued low outside temperature.

4. The kind and amount of attention available. This is least skillful and least frequent for owner operated residence installations and generally increases in skill as well as frequency as size of boiler increases. Local fuels and types of firing service must be considered carefully in this connection.

5. The kind of fuel to be used, including size and characteristics.

6. Size and height of the available chimney.

With the information contained in items 1 to 6 at hand, definite test information could be used as a basis for selecting the right size of boiler.

OTHER FACTORS IN SELECTION OF BOILER

As it will usually be found that several boilers will meet the specifications, the final selection of the boiler will be effected by other considerations as follows:

(*a*) dimensions of boiler, (*b*) height of water line, (*c*) durability under service, (*d*) convenience in firing and cleaning, (*e*) type of controls, (*f*) adaptability to changes in fuel and kind of attention, (*g*) the output required during the greater part of the season.

In large installations the use of several small units instead of one larger one will obtain greater flexibility and economy by permitting the operation of a required number of units according to heat requirements at the best operating efficiency.

NUMERICAL VALUE OF MAXIMUM HOURLY OUTPUT

Experience with gas-fired boilers, which are rated on B.t.u. output and can only slightly exceed the rated output, but which require no chimney draft, has shown that a continuous output capacity of 25 per cent in excess of the normal heat loss of radiation plus piping is ample for all direct radiator installations. This would correspond to an output of 40 to 60 per cent in excess of the normal heat loss of the radiation depending upon the proportion of piping to radiation. Upon the basis of gas-fired boiler experience, a coal-fired or oil-fired boiler which could deliver a continuous average output of 25 per cent in excess of radiation and piping would be amply large for any job. This is true for an oil-fired boiler provided the known output of the combination of boiler, burner, and chimney is used. In the case of coal-fired boilers however, it is

generally necessary to make additional allowance for the following conditions which may obtain at the time when the maximum or pick-up load occurs. (*a*) insufficient draft, (*b*) poor quality of fuel, (*c*) fuel bed not in good condition, (*d*) inferior quality of attention, (*e*) necessity of firing a charge of fuel that will last for a long period.

The conditions (*a*) to (*e*) inclusive, reduce the output obtainable below that which could be obtained under good or normal conditions and necessitate an increase in normal output of boiler selected in order that when the normal output is decreased by effect of items (*a*) to (*e*) there will still be available a quantity of heat 25 per cent in excess of the radiation plus piping loss. Coal-fired boilers therefore are usually selected with a maximum continuous output 60 to 80 per cent in excess of heat output of radiation plus piping.

For large installations the boiler output required in excess of heat loss of radiation plus piping will be about as follows:

	Per Cent
School buildings without recirculation of air	50
School buildings with full recirculation of air	25
Buildings with periodical heating only	50
Other large buildings	25

For any boiler selected it is well to determine whether the rate of combustion (pounds of coal burned per square foot of grate per hour) likely to be required continuously for more than a few hours is obtainable and is low enough to prevent clinker trouble. With natural draft it is recommended that for *continuous* output (under favorable conditions) with a *minimum of attention* the following combustion rates be not exceeded:

TABLE 1. PRACTICAL COMBUSTION RATES FOR RELATIVELY SMALL COAL FIRED HEATING BOILERS OPERATING ON NATURAL DRAFT OF FROM ¼ IN. TO ½ IN. WATER

SQ. FT. GRATE	KIND OF COAL	LB. OF COAL PER SQ. FT. GRATE PER HOUR
Up to 4	No. 1 Buckwheat Anthracite	3
5 to 9	No. 1 Buckwheat Anthracite	3½
10 " 14	No. 1 Buckwheat Anthracite	4
15 " 19	No. 1 Buckwheat Anthracite	4½
20 " 25	No. 1 Buckwheat Anthracite	5
Up to 9	Anthracite Pea	5
10 to 19	Anthracite Pea	5½
20 " 25	Anthracite Pea	6
Up to 4	Anthracite Nut and Larger	5
5 to 9	Anthracite Nut and Larger	6
10 " 14	Anthracite Nut and Larger	7
15 " 19	Anthracite Nut and Larger	8
20 " 25	Anthracite Nut and Larger	9
Up to 4	Bituminous	4
5 to 14	Bituminous	7
15 and above	Bituminous	10

In the case of boilers having larger grates, better draft and more constant attention, rates of combustion may be greatly increased over those shown in Table 1. For further data on this see Chapter VI on Chimneys and Chapter VII on Mechanical Draft.

BOILER RATINGS

There are wide differences in the ratings of heating boilers by the various manufacturers due largely to the fact that there has never been any generally accepted code upon which to base the rating of these boilers. The AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS, *the National Boiler and Radiator Manufacturers Association*, and others interested are making progress in the development of such a code.

COAL FIRED BOILER RATING

At present the word rating of coal-fired boilers may have any one of the following meanings:

1. The actual amount of equivalent direct radiator load that may be attached. It is assumed that the boiler has sufficient reserve to compensate for piping, pick-up load and other allowances.

2. The total equivalent direct radiation load plus piping load that may be attached. A boiler installed on a job with the proper amount of radiation, if selected according to this rating, will operate continuously at rating when the inside and outside temperatures are those for which the heat loss of building was figured. It is assumed that the boiler has sufficient reserve for pick-up load.

3. The output in B.t.u. at the boiler outlet when burning per hour certain percentage of the total fuel that can be fired at one time. The amount of fuel that can be fired at one time is determined by computation from firebox dimensions or by laboratory test. The output obtainable must be found by test. This method of rating has been popular for boilers burning anthracite in sizes larger than chestnut. When the length of time between successive firings is given the boiler is said to be rated upon that *firing period*, e.g. If boiler has to be fired every eight hours when delivering its rated output, the boiler is rated on an *8 hour firing period.*

4. The output in B.t.u. that can be obtained with a good grade of anthracite or bituminous coal with attention limited according to directions specified by the manufacturer. With proper specifications regarding fuels, firing, attention and operation, this method of rating is useful in that it is applicable to all types of fuels.

5. The output obtained when burning a specified fuel at a specified rate of combustion. The output must be found by test when burning the fuels selected as standard. The rate at which the fuel is burned is based upon experience and is varied according to an arbitrary rule according to kind of fuel and size of grate. The output for fuels other than standard is found by multiplying the output for standard fuel by a correction factor.

6. The output obtained when the temperature of gases leaving the boiler is not over a specified degree and the carbon dioxide is above a certain minimum.

This method has been suggested but has not been used.

7. The output obtained by multiplying the surface with which the fire and gases come in contact by the average amount of heat which a square foot of surface will deliver to the water in the boiler.

The heat transmitted per square foot of surface and used in this method of rating is established arbitrarily. The boiler is said to be rated on its heating surface,

8. A method sometimes used for estimating the approximate reasonable output of a boiler where more accurate and reliable test data are not available, is as follows:

The output in B.t.u. is obtained by multiplying together the square feet of grate surface by an assumed rate of combustion (in lb. of coal per sq. ft. of grate per hour) by the B.t.u. value of the fuel (per lb.) by the efficiency of the boiler (at the load and rate of combustion assumed).

This gives an approximate rating. For data on rates of combustion, see Table 1. Also Chapter VI on "Chimneys" and Chapter VII on "Mechanical Draft." Ordinary heating boiler efficiencies for normal rate of combustion may vary from 55 to 75 per cent.

GAS FIRED BOILER RATING

The rating of gas boilers in contrast to coal boilers is a comparatively simple matter. The following conditions of rating established by the *American Gas Association* have been generally accepted:

1. The boiler must deliver rated output without chimney connection.
2. There must be no carbon monoxide formed when the gas pressure in service line is normal, 50 per cent below normal, or 50 per cent above normal.
3. The boiler must have an efficiency of at least 75 per cent at rated output.

The maximum B.t.u. input or gas that can be burned may be determined by the manufacturer but is checked by the *American Gas Association* Laboratory before being approved. An arbitrary efficiency of 80 per cent is assumed in computing the output rating from the B.t.u. input.

The actual B.t.u. delivered by any gas boiler when burning gas at the rated B.t.u. input will vary from the *A. G. A.* output rating in the direct proportion of the boilers actual efficiency with the gas being burned to 80 per cent.

RATINGS OF BOILERS FOR OIL FUEL

The output of a boiler with oil fuel will depend upon the combined efficiency of the boiler and burner and the quantity of oil that can be properly burned within the space provided in the boiler.

Oil burner ratings in use at present have been obtained either from test with typical burners or have been obtained by multiplying the coal rating by a constant.

Coal boilers converted to oil may have as high or a higher rating and as high or higher efficiency than with coal.

SIZE, RATING AND CAPACITY OF A BOILER

The three words are sometimes used indiscriminately to designate any one of the three things for which they should be used.

Size may be: the physical dimensions of all or part of the boiler, the maximum output, or the manufacturers rating. This word has been used loosely so long that it would be difficult to limit it to one meaning.

Rating usually means the boiler *output* under certain conditions. It is important that the conditions be known in order to give rating a definite meaning.

Capacity is another word for output. It may be stated in terms of pounds of steam delivered, square feet of standard radiation supplied with heat, or B.t.u. delivered. The word *output* will convey the meaning better than *capacity*.

TYPES OF BOILERS

Owing to the changes which have been made in boiler design within the last six or seven years, it is no longer correct to draw general conclusions regarding the different types of boilers such as cast-iron sectional, steel fire-tube and steel water-tube boilers.

Broadly speaking, three types of heating boilers are commonly used.

Sectional boilers, may be of the rectangular pattern with vertical sections, or of the round pattern with horizontal sections. They are usually constructed of cast iron; and on account of their sectional construction and the usual practice of being shipped knocked down and assembled on the job, they are easily handled through small openings at any stage of construction. Their design also facilitates the removal and replacing of damaged parts as well as an increase or decrease in capacity by the addition or removal of sections.

Cast-iron boilers are limited to operating pressures of 15 lb. steam or 30 lb. water, excepting when used for hot-water supply, in which case the boilers are built for operation at city pressure and are tested at pressures two and one-half times the operating pressure.

The fire-tube boiler, which may be of the horizontal tubular brick set pattern, the horizontal tubular firebox pattern (with or without supplementary brick setting), the vertical tubular brick set pattern or the vertical tubular firebox pattern.

Fire-tube steel boilers may be built for high or low pressure, but when used for heating with consequent usual low pressure operation, they are generally built according to the *A. S. M. E.* Steel Plate heating boiler code which limits working pressure to 15 lb. per sq. in. for steam boilers or 250 deg. fahr. or 160 lb. per sq. in. for water boilers. In construction they may be riveted or welded. Where higher operating pressures (e.g. up to 100 lb. per sq. in.) are required, boilers of the same dimensions as low pressure boilers can be obtained at a comparatively small increase in cost.

Low pressure operation is favored because of greater possible operating economy due to lower temperature of the water in the boiler. The large water content provide for heat storage capacity and minimized water line fluctuation under sudden variations in load. Chimney heights for the larger sizes of fire-tube boilers as specified by the manufacturer are generally lower than for corresponding sizes of cast-iron boilers.

The water-tube boiler, which may be of the horizontal brick set pattern with either horizontal or cross drums, the vertical brick set pattern, the bent or inclined tube brick set pattern, or the self-contained firebox pattern with any one of the above arrangements of tubes.

Water-tube boilers are usually constructed with steel or iron tubes, steel drums and either steel, cast steel or cast-iron headers. They heat up and steam rapidly and also lose their heat and steam pressure quickly. The water and steam spaces are moderate and their performance on rapid and wide variations of load is accordingly responsive.

The principal heating surface consisting of tubes with the water inside and the heated gases outside, is easy to clean from the inside with hydraulic or pneumatic tube cleaners and from the outside with steam or air jet soot blowers, although with highly scaling waters are to be avoided since the scale formation on the inside of the small tube may be comparatively rapid.

The water line is generally high and considerable head room is required. On account of being constructed with drums and banks of tubes they

may be shipped knocked down and assembled on the job, thus passing through small openings at any stage of the construction.

INSTALLING AND PREPARING BOILER FOR SERVICE

Manufacturers directions should always be read before assembly or installation of any boiler is begun even if the contractor is familiar with the boiler. All joints requiring boiler putty or cement which cannot be reached after assembly is complete must be carefully finished as assembly progresses as even small openings permitting short circuiting of gases hardly ever fill up during operation.

Nuts or tie rods of sectional cast-iron boilers must always be loosened about one thread to allow for expansion of boiler when hot. The nuts should be just a little more than hand-tight when the boiler is at its operating temperature.

Flow piping connections should be full size of manufacturers outlet and should preferably be vertical from outlets to a height of 2 or 3 ft. above boiler wherever possible. Vertical piping and low outlet velocity are of great value in keeping the steam dry especially if the boiler accumulates grease and oil from the system. Steam velocities of 20 to 25 ft. per second are recommended for the maximum continuous boiler output. Where optional outlets are provided, those on steam boilers should be in the least active parts, whereas, those on water boilers should be on the most active parts.

If lack of head room necessitates a low vertical connection from boiler to steam main, it is advisable to make a drip connection to the return at first change of direction of the main.

Recommended methods of connecting piping to steam boilers are shown in Chapter III, Steam Heating Systems and Piping.

CLEANING BOILERS

Grease serves as a carrier for sand and dirt in the system with the result that a scum of fine particles and grease accumulates on the surface of the water in the boiler while heavier particles settle to the bottom of the boiler or remain in suspension. The scum is best removed through an outlet at the surface of the water. The method given below has been used successfully.

Connect a pipe (full size of opening at boiler) from the surface blow-off tapping or opening nearest surface to a convenient drain. Raise water level in boiler to bottom of blow-off. Build a brisk fire in the boiler and raise pressure between 5 and 10 lb. Open valve and keep it open as long as pressure remains. Close valve when necessary to enable boiler to build up pressure, then open and proceed as before. Keep water level at the bottom of the blow-off by feeding fresh water. Continue blowing until water in blow-off is clean. The fire should then be removed and the water drained preferably under steam pressure from the bottom of boiler to remove heavy particles and material in suspension.

Where appreciable dirt and grease are present it is advisable to add soda ash to the water in the boiler before boiling out.

Refill boiler with water to proper level before starting fire.

On new jobs it is advisable wherever possible to drain condensation directly to sewer during first week of operation, thereby preventing passage of grease and dirt to the boiler from the system. The length of time fresh water should be fed to the boiler will depend somewhat on the amount of scale forming material in the water, as it would be objectionable to accumulate scale on the heating surfaces.

PROTECTION OF BOILERS

The following precautions should be taken in all installations to prevent damage to the boiler:

1. Proper and convenient drainage connections for use if boiler is not in operation during freezing weather should be provided.
2. Strains on boiler due to movement of piping during expansion should be prevented by suitable anchoring of piping and proper provision for pipe expansion.
3. Direct impingement of intense local heat upon any part of surface should be avoided by protecting surface with fire brick or other insulating material.
4. Condensation must flow back to boiler as rapidly and uniformly as possible. Return connections should prevent water from backing out of boiler.
5. Low water cut-off devices which shut off the source of heat if the water in boiler falls below a safe level are recommended for boilers fired with oil or gas.
6. In single boiler installations the steam and return main should be free of valves.

SMOKE BREECHING AND CHIMNEY CONNECTIONS

Connections from boiler outlet to chimney should be air-tight and as short and direct as possible, preference being given to long radius and 45 deg. instead of 90 deg. bends. The bend at entrance to chimney should not project beyond inside of chimney. Where a battery of boilers are connected into a breeching each boiler should be provided with a tight damper. Good connections made to a good chimney will usually result in a rapid response by boiler to demands for heat.

COMPLETING INSTALLATION

In addition to the usual examination to insure that all work is done in a workmanlike manner and that the system is free of leaks, a check should be made on the following:

1. Whether boiler has sufficient draft to burn the amount of fuel which would be required during pick-up period in cold weather.
2. That boiler operates with a steady water line and condensation returns rapidly to boiler.
3. That rods and levers of pressure or temperature control apparatus are adjusted to proper length.
4. That any safety equipment used works properly.

BOILER TROUBLES

A complaint regarding boiler operation will generally be found to be one of the following:

1. *The boiler fails to deliver enough heat.* The cause of this condition may be: (*a*) poor draft, (*b*) poor fuel, (*c*) inferior attention or firing, (*d*) boiler too small, (*e*) improper

piping, (*f*) improper arrangement of sections, (*g*) heating surfaces may be covered with soot and (*h*) insufficient radiation installed.

2. *The water line is unsteady.* The cause of this condition may be: (*a*) grease and dirt in boiler, (*b*) water column connected to a very active section and therefore may not be showing actual water level in boiler, (*c*) boiler operating at excessive output.

3. *Water disappears from gage glass.* This may be caused by: (*a*) priming due to grease and dirt in boiler, (*b*) too great pressure difference between supply and return piping causing water to back into return, (*c*) valve closed in return line, (*d*) connection of bottom of water column into a very active section or thin waterway, (*e*) improper connections between boilers in battery permitting boiler with excess pressure to push water into boiler with lower pressure.

4. *Boiler causes water to be carried into steam main.* This may be caused by: (*a*) grease and dirt in boiler, (*b*) insufficient steam dome or too small steam liberating area, (*c*) outlet connections of too small area, (*d*) excessive rate of output, (*e*) water level carried higher than specified.

5. *Boiler is slow in response to operation of dampers.* This may be due to: (*a*) poor draft due to air leaks into chimney or breeching, (*b*) inferior fuel, (*c*) inferior attention, (*d*) accumulation of clinker on grate, (*e*) boiler too small for the load.

6. *Boiler requires too frequent cleaning of flues.* This may be due to: (*a*) poor draft, (*b*) smoky combustion, (*c*) too low a rate of combustion, (*d*) too much excess air in firebox causing chilling of gases.

7. *Boiler smokes through fire door.* This may be due to: (*a*) defective draft in chimney or incorrect setting of dampers, (*b*) air leaks into boiler or breeching, (*c*) gas outlet from firebox plugged with fuel, (*d*) dirty or clogged flues.

If boiler trouble is attributed to oil and dirt in boiler one of the following tests will determine whether cleaning of boiler is necessary:

1. Draw off a small quantity of water from the try-cock near the water line. Boil this water in a pan and at the same time boil an equal quantity of water such as fed to boiler in another pan (of same size if available.) A marked difference in liberation of steam from the surface will indicate that the boiler should be cleaned.

2. After building a pressure in the boiler of 2 to 5 lb. open safety valve by means of a wire attached to lifting lever. Keep valve open for one minute. If water is discharged with the steam after the first rush of steam and water, it can safely be assumed that the boiler should be cleaned.

OPERATING BOILERS WITH VARIOUS FUELS

To keep the fuel bed in proper condition, the following general rules should be observed:

1. Remove ash from fuel bed by shaking the grates whenever fresh fuel is fired. This removes ash from the fire; enables the air to reach the fuel and does away with the formation of clinker (which is melted ash).

2. Supply the boiler with a deep bed of fuel. Nothing is gained by attempting to fire a small amount of fuel. A deep bed of fuel secures the most economical results.

3. Remove ash from ashpit at least once daily. Never allow ash to accumulate up to the grates. If the ash prevents the air from passing through, the grate bars will burn out and much clinker trouble will be experienced.

USE OF SECONDARY AIR

Secondary or auxiliary air (air supplied over the fuel bed), should be provided whenever it increases the temperature in the firebox. After firing considerable combustible gas rises from any fuel and enough air for its combustion cannot be supplied through the fuel bed, but must be provided by other means, usually through a slide damper in the fire door.

Too much secondary air will cool these gases below the ignition point, and prove harmful rather than beneficial.

The amount of secondary air required depends on so many variables, that it is impossible to make a set of rules to fit all cases.

The following suggestions will be helpful: (*a*) In cold weather, with high combustion rates, the secondary air damper should be half open all the time. (*b*) In very mild weather with a very low combustion rate, the secondary air damper should be closed all the time. (*c*) For temperature between very mild and very cold, the secondary air damper should be in an intermediate position. (*d*) For ordinary house operation, secondary air is needed after each firing, for about one hour.

Secondary air, when used with bituminous coal, serves the purpose of preventing smoke as well as increasing the efficiency by burning the gas escaping from the fuel bed. As a guide to the amount of secondary air required, the user should supply just enough secondary air to eliminate the smoke.

BURNING VARIOUS TYPES OF FUEL

It is advantageous to be able to burn several types of fuel. The boiler may be designed for one particular type of fuel, but a knowledge of the method of handling other fuels often makes it possible to obtain satisfactory results with other available fuels.

Anthracite

Anthracite coal has a heat value of from 11,600 to 13,500 B.t.u. per pound and ash content of from 10 to 20 per cent.

An anthracite fire should never be poked as this serves to bring ash to the surface of the fuel bed where it melts into clinker.

Grate size is suitable for large grates and a fuel depth of 20 in. or more. The air spaces are large; the amount of surface in contact with the air is small, and consequently combustion is slow. Lumps of rock or slate, being large, may cause trouble in shaking of the grate. On grates, 25 in. and under, the fire is likely to go out easily with this fuel, unless mixed with small coal for reducing the air spaces.

Egg size is suitable for large firepots (grates 25 in. and over) if the fuel can be fired at least 20 in. deep. The air spaces between the pieces of coal are large and combustion is slower than with the next smaller size, although more rapid than with grate coal. This coal should be clean and high in calorific value. The rock and slate pieces may be large enough to cause some trouble in shaking the grate. For best results this coal should be fired deep. The grate should be shaken before every firing. An anthracite fire should never be poked as this only brings ash to the surface of the fuel bed where it melts into clinker.

Stove size coal is the popular size of anthracite fuel for most sizes of heating boilers. It is small enough to burn well on grates 17 in. and above, but large enough so that the draft loss through the fuel bed is not too great. The refuse in the coal is not large enough to cause any trouble in shaking of the grates. About the only instructions needed for burning this type of fuel are: The grate should be shaken before each firing; the fire should never be poked from the top; the fuel should be fired deep and uniformly.

Chestnut size coal is in demand for firepots up to 20 in., and especially those in which the fuel cannot be fired over 18 in. deep. The percentage of ash is higher than in stove coal, but the pieces of rock and slate are small and do not interfere with the shaking of the grates.

Pea size coal is often an economical fuel to burn. It is low in price. When carefully fired pea coal can be burned on regular grates. It is well to have a small amount of a larger fuel on hand when building new fires, or when filling holes in the fuel bed. Care should be taken to shake the grates only until the first bright coals begin to fall through the grates. The fuel bed, after a new fire has been built, should be built up by addition

of small charges until at least level with the sill of the fire door. This keeps a bed of ignited coal in readiness when a sudden demand for heat is made on the boiler. When firing, the bright fuel should either be pulled forward or pushed to the back of the firepot, leaving a hollow in which to fire the fresh fuel and leaving a portion of the glowing coal exposed, to ignite the gases rising from the fuel, otherwise a gas explosion may occur.

This fuel requires a strong draft and therefore the best results will generally be obtained by keeping the choke damper open, the cold-air check closed and controlling the fire by means of the air-inlet damper only.

Buckwheat size coal requires the same type of attention as pea size. The smaller size of the fuel makes it more difficult to burn on ordinary grates. Even greater care must be taken in shaking than with pea coal, lest the fuel run through the grate. A good draft is required and consequently the fire is best controlled by the air-inlet damper only. Where frequent attention can be given and where there is not a big heat demand on the boiler, this fuel is frequently burned without the aid of any special equipment.

In general it will be found more satisfactory with buckwheat coal to keep a uniform heat output and consequently to keep the system warm all the time, rather than to allow the system to cool off at times and then to attempt to burn the fuel at a high rate while warming up. A uniform low fire will minimize the clinker formation and keep the clinker in an easily broken up condition so that it can be easily shaken through the grate.

Forced draft and special grates or retorts are frequently used with this fuel for best results. (See Chapter VII.)

Coke

Coke is a very desirable fuel and will usually give satisfaction as soon as the user learns how to control the fire. Coke ignites and burns very rapidly with less draft than anthracite. In order to control the air admitted to the fuel it is very important that all openings or leaks into the ashpit be tightly closed. A coke fire responds more rapidly than anthracite to the opening of the dampers. This is an advantage in warming up the system, but it also makes it necessary to watch the dampers more closely in order to prevent the fire from burning too rapidly. A deep bed of coke should always be carried. The grates should be shaken only slightly in mild weather, and should only be shaken until the first red particles drop from grates in cold weather. Since coke only weighs about half as much as anthracite per cubic foot, and therefore only about half as much can be put in the firepot, it will be necessary to fire oftener, but during the greater part of the heating season this will not be an item of importance. The best size of coke for general use will be that which passes over a 1 in. screen and through a 1½ in. screen for small firepots where the fuel depth is not over 20 in. For large firepots where the fuel can be fired over 20 in. deep, coke which passes over a 1 in. screen and through a 3 in. screen will be most satisfactory. Large sizes of coke should either be mixed with fine sizes or should be broken up before using.

Kinds of Bituminous Coal

Solid fuels, excepting anthracite and coke, can be classified, from the standpoint of the user, into four types, as follows: (*a*) caking bituminous coal, (*b*) non-caking bituminous coal, (*c*) semi-bituminous coal and (*d*) lignite.

The characteristics of these coals are as follows:

Bituminous coal generally has a high heat value (from 12,000 to 14,500 B.t.u. per pound) and a percentage of ash of 5 to 15 per cent.

Caking coal forms a cake or crust over the fire as soon as heated. This crust, when broken up, gives a fire that burns like coke. Some types of caking coal are very easily broken up, even in handling, and as a result are very fine when fired, while others are quite strong so that the percentage of lumps is high. The heat value of a fine coal may be even greater than the heat value of the coal containing some lumps, but for general operation, the coal containing the larger percentage of lumps will be most satisfactory. A fine coal forms a blanket over the fire, tending to reduce the rate of combustion and also to increase the loss due to falling of coal through the grate, whereas a coal with a larger percentage of lumps allows the air to pass through the fuel bed more easily and also prevents, to a certain degree, the formation of a solid crust such as produced by the fine coal.

The *non-caking coal* does not form a coke or crust when heated, but burns practically without attention because the air can pass freely through the fuel bed. This coal is best

adapted to use when it contains a large percentage of lumps or when it is uniformly sized, since the fine coal will cause a considerable loss by falling through the grates.

Semi-bituminous coal, because it has only a small percentage of smoke forming gaseous matter, is easily burned without smoke and is an excellent fuel. As a rule it is very easily broken up in handling and may therefore be quite fine. This coal forms a cake like caking soft coal and consequently requires the same attention.

If the coal is very fine so that a considerable percentage falls through the grate it will be advantageous to wet the coal before firing, in order to hold the fuel particles together until it cakes.

Lignite

Lignite is a free burning coal containing a high percentage of volatile matter in addition to a high percentage of moisture. The high percentage of moisture prevents easy ignition and causes breaking of the coal, when heated, into fine particles which may fall through the grate. For general use this coal is most satisfactory if broken into lumps of 3 in. size soon after mining and dried by exposure to the air. The ash from lignite resembles wood ash, does not clinker and generally falls through grate without shaking. Grates with small air spaces, especially those preventing falling of fuel into ashpit, are preferred for lignite.

HOW TO FIRE BITUMINOUS COAL

Bituminous coal should never be fired over the entire fuel bed at one time. A portion of the glowing fuel should always be left exposed to ignite the gases leaving the fresh charge.

Air should be admitted over the fire through the special secondary air device, or the slide in fire door or by opening the fire door slightly. If the quantity of air admitted is too great the gases will be cooled below ignition temperature and will fail to burn. The fireman can best judge the quantity of air to admit by noting when the air supplied is just sufficient to make the gases burn rapidly and smokelessly above the fuel bed.

The red fuel in the firebox, before firing, excepting for a shallow layer of coke on the grate, should be pushed to one side or forward or backward to form a hollow in which to fire fresh fuel. (Some manufacturers recommend that all red fuel be pushed to rear of firebox and that the fresh fuel be fired directly on the grate and allowed to ignite from the top. The object of this is to reduce the early rapid distillation of gases and to reduce the quantity of secondary air required for smokeless combustion.)

It is well to have the bright fuel in the firebox so placed that the gases from the freshly fired fuel, mixed with the air over the fuel bed, pass over the bed of bright fuel on the way to the flues. The bed of bright fuel then supplies the heat to raise the mixture of air and gas to the ignition temperature, thereby causing the gaseous matter to burn and preventing the formation of smoke.

The fuel bed should be carried as deep as the size of fuel will permit in order to have as much coked fuel as possible for pushing to the rear of the firebox at the time of firing. A deep fuel bed obtains the longest firing intervals.

If coal is of the caking kind the fresh charge will fuse into one solid mass which can be broken up with the stoking bar and levelled from 20 minutes to one hour after firing, depending on the temperature of the firebox. Care should be exercised when stoking not to bring the bar up to the surface of the fuel as this will tend to bring ash into the high temperature zone at the top of the fire, where it will melt and form clinker. The stoking bar should be kept as near the grate as possible and should be raised only enough to break up the fuel. With fuels requiring stoking it may not be necessary to shake the grates as the ash is usually dislodged during stoking.

The output obtained from any boiler with soft coal will usually exceed that obtainable with anthracite since soft coal burns more rapidly than hard coal and with less draft. Soft coal however will require quite frequent attention to fuel bed because it burns unevenly, even though the fuel bed is level, forming holes in the fire which admit too much air, chilling the gases over the fuel bed and reducing the available draft.

PREPARING FOR PICK-UP LOAD

The period of maximum heat demand should be anticipated in order that ash and clinker can be removed and enough fuel fired to have a deep

fuel bed well ignited at the beginning of this period. This is even more important with anthracite than with bituminous due to the slower ignition of the former.

In extremely cold weather, which occurs at most only during the few days per season, it is advisable, *if the reserve output of the boiler is small*, to keep the room temperature normal continuously to eliminate the peak demand due to pick-up of temperature.

CLEANING FLUES

All boilers are provided with flue clean-out openings through which the heating surface can be reached by means of brushes or scrapers. Flues of solid fuel boilers should be cleaned often to keep surface free of soot or ash. Gas-boiler flues and burners should be thoroughly cleaned once a year. Oil-burning boiler flues should be examined periodically to determine when cleaning is necessary.

CARE OF HEATING BOILERS WHEN NOT IN USE

During summer months more damage is frequently done to heating boilers than during the period of operation. This is due chiefly to acid formed by deposits on the surface of sulphur from the fuel and the moisture in the cellar air during summer. At the end of the heating season the following precautions should be taken:

1. All heating surfaces should be thoroughly cleaned, steel boiler being given a coating of lubricating oil.
2. All machined surfaces should be coated with oil or grease.
3. Connections to chimney should be thoroughly cleaned and in case of small boilers the pipe should be placed in a dry place after cleaning.
4. If there is much moisture in the boiler room, it is advisable to drain the boiler to prevent condensation of moisture on surface when boiler temperature is lower than the dew-point. In steel boilers kerosene poured on surface of water will form a protecting film over the inside surface as the water is drained out.
5. When the boiler room is comparatively dry, in the case of cast-iron boilers, the water level should be raised into the steam riser to exclude air from the boiler. A hot-water system is usually left filled to the expansion tank.
6. The grates and ashpit should be thoroughly cleaned.

Enough water only should be added to heating boilers to keep the level, when water is heated, at the height established by the manufacturer. Raising the water to a higher level may result in carrying of moisture with the steam. Water should not be used or allowed to be lost by leakage from heating systems as the fresh water required to make up the loss may introduce scale forming or corrosive matter.

HOT WATER SUPPLY BOILERS

Boilers for hot-water supply are classified as direct if the water heated passes through the boiler and as indirect if the water heated does not come in contact with the water or steam in the boiler.

Direct heaters are built to operate at the pressures found in city supply mains and are tested at pressures from 200 to 300 lb per square inch. The life of direct heaters depends on corroding properties of the water

supplied and the amount of water passed through the heater. If water temperatures are maintained below 140 deg. the life of the heater will be much longer than if higher temperatures are used owing to decreased scale formation and minimized corrosion below 140 deg. Direct water heaters in some cases are designed to burn refuse and garbage.

Indirect heaters generally consist of a steam boiler in connection with a coil or tube heater which transmits the heat in the steam to the water. This type of installation costs more than a direct system but has the following advantages:

1. The boiler operates at low-pressure. Water hammer and cold water shocks are not transmitted to the boiler.
2. The boiler is protected from scale and corrosion.
3. The scale is formed in the heat exchanger in which the parts to which the scale is attached can be cleaned or replaced. The accumulation of scale does not effect efficiency although it will effect the capacity of the heat exchanger.
4. No pounding occurs in tank due to formation of steam, especially if the steam supply to the heater is under automatic control.
5. Discoloration of water may be prevented if water supply only comes in contact with non-ferrous metal.

SELECTION OF HOT WATER SUPPLY BOILERS

The size of hot-water supply boiler selected is based upon: the quantity of water used in 24 hours, the temperature rise, the peak load, the duration of peak load, and the size of storage tank used. A boiler capable of delivering per hour 1/24 of the 24-hour demand operating continuously would be sufficiently large, but it is good practice to provide 20 per cent reserve capacity in the boiler by selecting a boiler which can deliver per hour 1/20 of the 24-hour demand. The storage tank should be of such size that the water stored during off peak hours, plus the hourly output of the heater will equal the demand during the period of peak load.

If the storage tank is already installed and is too small, a larger boiler must be used, the boiler having such capacity that the stored water plus the hourly heat output of the boiler equals the demand during the peak period.

Control of tank temperature by means of tank thermostat and means for operating dampers or regulating gas or oil supply is discussed in Chapter XVI on Automatic Heat Control.

For determination of hot-water supply requirements the reader is referred to Chapter XX on Water Supply Systems and Piping.

Hot-water supply boilers are usually rated in gallons of water heated through a specified temperature rise within a given time. It is important to determine the temperature rise and the time required as there is considerable variation in the values as used by different manufacturers.

CHAPTER VI

CHIMNEYS

Functions of the Chimney; Draft, Friction Losses, Chimneys for Heating Boilers, Warm-Air Furnaces, Oil Burners, Gas Appliances, Details of Construction, Underwriters' Rules.

THE functions of a chimney are, generally speaking, twofold: (1) to produce the required draft, (2) to carry off the products of combustion and discharge them so as not to become a nuisance.

Where natural draft is employed the required draft is made up of: (*a*) that required to overcome the friction and to produce the velocity of the air at entrance to the furnace, (*b*) plus that necessary to force the air through the fuel bed (if any), (*c*) plus that necessary to produce the velocity and to overcome the friction of the products of combustion in their passage through the boiler, (*d*) plus that necessary to produce the velocity and to overcome the friction of the products of combustion in their passage through the breeching, from the boiler to the chimney, (*e*) plus that necessary to produce the velocity and to overcome the friction of the products of combustion in their passage through the chimney itself.

Where forced draft is employed factors (*a*) and (*b*), of the required draft, are usually taken care of by the forced draft apparatus, leaving the factors (*c*), (*d*) and (*e*) only, to be taken care of by the chimney.

Where induced draft is employed the entire draft required is generally taken care of by the induced draft apparatus.

In the case of either forced or induced draft any part of the required draft may be taken care of by the chimney and the remainder by the apparatus, but the exact conditions to be met in this respect should be known and the chimney should be proportioned accordingly.

This combination of natural and mechanical draft is frequently used, especially where loads are quite irregular, so that the plant may be run on natural draft during light loads and on mechanical draft during peak-loads, only. This combination also affords a factor of safety against breakdowns in the mechanical draft equipment, since at least a partial load may always be carried on natural draft.

Draft measurement is usually in inches of water by which is meant the static head of water (in inches) corresponding to the difference in pressure between any point in the boiler, breeching or chimney, at which the draft is being measured, and the pressure of the surrounding atmosphere. One inch of draft is equivalent to 5.2 lb. per square foot of pressure difference.

The theoretical draft of a chimney is the hypothetical draft that would be produced if the chimney were completely heated and filled with the

---

Material for this Chapter prepared especially for THE GUIDE by the following committee: George A. Orrok, *chairman;* E. K. Campbell, J. R. McColl and L. W. Millis.

normal gases of combustion, at the average temperature for which the chimney was designed, and then the flow of these gases was suddenly stopped. This theoretical draft can never be attained in practice, but it is the basis of all scientific chimney design.

The general formula for the theoretical draft of a chimney, with all observable factors taken into account, is expressed by equation (1).

$$D_t = 6.43\, H\, P_o \left(\frac{W_o}{T_o} - \frac{W_g}{T_c} \right) \qquad (1)$$

where

D_t = theoretical draft in inches of water.
H = height of the chimney above grate bars, in feet.
P_o = pressure of the atmosphere in pounds per square inch.
W_o = weight of air (at 32 deg. fahr.) in pounds per cubic foot.
W_g = weight of the flue gas (at 32 deg. fahr.) in pounds per cubic foot.
T_o = absolute temperature of the air in deg. fahr.
T_c = average, absolute temperature of the gases in the chimney in deg. fahr.

For an atmospheric pressure of 14.7 lb. and a weight of air equal to the weight of the flue gases (at 32 deg. fahr.) of 0.08071 lb. per cubic foot this formula reduces to

$$D_n = 7.63 \left(\frac{1}{T_o} - \frac{1}{T_c} \right) \qquad (2)$$

where

D_n = the normal theoretical draft per foot of height of chimney under usual atmospheric conditions at sea level.

For a temperature of 0 deg. fahr. outside and an average temperature of 600 deg. fahr. in the chimney this reduces to 0.0094 in. of draft per foot of chimney height.

TABLE 1. CORRECTIONS IN INCHES OF WATER PER FOOT OF CHIMNEY TO BE DEDUCTED FROM THE THEORETICAL DRAFT FOR OTHER THAN A 0.08071 LB. PER CUBIC FOOT (AT 32 DEG. FAHR.) DENSITY OF FLUE GAS

TEMPERATURE OF FLUE GAS DEG. FAHR.	DENSITY OF FLUE GAS IN POUNDS PER CUBIC FOOT AT 32 DEG. FAHR.	CORRECTION DEDUCTION IN INCHES OF WATER PER FOOT OF HEIGHT
400	0.08071	0
600		
800		
400	0.0820	0.00014
600		0.00011
800		0.00009
400	0.0830	0.00025
600		0.00020
800		0.00017
400	0.0840	0.00036
600		0.00030
800		0.00025
400	0.0855	0.00053
600		0.00043
800		0.00036

The correction factor for changes in atmospheric pressure, ranges from 68 per cent at 10 lb. pressure to 100 per cent at 14.7 lb. pressure, in direct proportions to the pressure.

The corrections for different densities of flue gas are shown in Table 1.

The available draft of a chimney is the theoretical draft after deducting the various losses back to the point of reference, such as at the base of the chimney or the furnace of the boiler. Ordinarily the point at which the available draft is measured is in the furnace directly above the fuel bed.

The losses which must be deducted from the theoretical draft to obtain the available draft at this point are as follows: (1) the velocity and friction losses in the chimney, (2) the velocity and friction losses in the breeching and (3) the velocity and friction losses in the boiler.

The loss due to velocity of the flue gases in the chimney is expressed by equation (3).

$$D_{cv} = 0.1185 \frac{V_c^2}{T_c} = 0.193 \frac{Q^2}{D^4 T_c} = 0.0001222 \frac{W^2 T_c}{D^4} \qquad (3)$$

where

D_{cv} = loss of draft due to velocity in the chimney.
V_c = velocity of the chimney gases in feet per second.
Q = cubic feet of gas flowing per second.
D = diameter of a circular chimney in feet.
W = weight of gases flowing in pounds per second.

All for a flue gas and air weight of 0.08071 lb. per cubic foot (at 32 deg. fahr.) and an atmospheric pressure of 14.7 lb.

The correction factor for different weights of flue gas run from 100 per cent at a weight of 0.08071 lb. per cubic foot (at 32 deg. fahr.) to 109 per cent at a weight of 0.088 lb. per cubic foot in direct proportion to the flue gas weight.

Equation (3) gives the loss due to velocity in the chimney in terms of the velocity, the quantity and the weight of the gases flowing, so that this loss may be figured from either of these factors, which may be known.

The loss of draft due to the friction of the gases in the chimney is expressed by equation (4).

$$D_{cf} = 0.0076 \frac{V_c^2 L}{T_c D} = 0.0123 \frac{Q^2 L}{T_c D^5} = 0.0000078 \frac{W^2 T_c L}{D^5} \qquad (4)$$

where

D_{cf} = loss in draft due to friction in the chimney.
L = length of chimney (in feet) through which the gases pass; all for the standard condition heretofore specified. It will be noted that equation (4) also gives the loss in terms of the velocity, quantity and weight of gases flowing.

Equation (4) is for circular sections. For square sections the friction loss is approximately 62 per cent of that for circular section of a diameter equal to the width of the square when handling the same weight of gases per second.

The loss of draft in the breeching is expressed by equation (5).

$$D_b = 0.000955 \frac{W^2}{D^5_{br}} \qquad (5)$$

where

D_b = loss of draft in the breeching per foot of length and D_{br} = the width of the breeching in feet; all on the following basis: flue gas temperature of 600 deg. fahr. a flue gas density of 0.08071 lb. per cubic foot (at 32 deg.) coefficient of friction —0.016, standard atmospheric pressure and ratio of height to width of cross-section of a rectangular breeching of 2 to 1.

The correction factors for different atmospheric pressures and different flue gas densities are the same as given for the losses in the chimney.

The correction factor for different flue gas temperatures ranges from 0.8 at 400 deg. to 1.2 at 800 deg. based on the same weight of gas flowing per second.

The loss of draft in the turns of the breeching, including one right angle turn where the gases pass from the boiler to the breeching and another where they pass from the breeching to the chimney, is expressed in inches of water per right angle turn by equation (6).

$$D_{bt} = 0.0013 \frac{W^2 T_c}{A^2 W_g} \qquad (6)$$

where

A = area of breeching in square feet.

The loss of draft through the boilers varies very materially with the size and type of boiler, number of passes, sizes of tubes, etc., but may be taken from Table 2.

TABLE 2. AVERAGE FRICTION LOSS OF FLUE GASES IN PASSING THROUGH BOILERS

PER CENT RATING	100	150	200	250	300
Loss Ins., Water	0.1 to 0.3	0.2 to 0.6	0.3 to 0.9	0.5 to 1.4	0.7 to 1.9

By use of Tables 1 and 2 and equations (1) to (6) inclusive, the theoretical draft and the available draft of any chimney may be calculated under any given set of conditions.

The quantity of gases to be handled is quite variable, depending upon the fuel and the proportion of air used.

The theoretical amount of air required per pound of coal is approximately 12 lb. Fifty per cent excess air is generally allowed, which means that 19 lb. of flue gas may be used per pound of coal burned. The pounds of coal burned per horsepower developed will depend upon the efficiency of the boiler plant but will usually fall between four and five.

The horsepower rating of a chimney is usually a fallacy, except for the smaller plants operating under standard conditions for which the horsepower ratings of the chimney may have been computed. The horsepower capacity of a chimney depends not only upon the many variables already referred to, but also upon the efficiency of the boiler plant, the fuel used and the rate of combustion required to develop the required output.

For instance a chimney which would produce 1 in. of available draft under a load of 100 hp. in a plant using 4 lb. of coal per horsepower with

a combustion rate of 30 lb. of anthracite pea coal per square foot of grate, would prove entirely inadequate for a 100 hp. load on a boiler plant using 5 lb. of No. 3 buckwheat coal per horsepower at the same combustion rate.

While as can readily be seen this method of proportioning chimneys according to horsepower is very approximate, it is frequently used with a fair degree of safety for small plants operating under ordinary conditions.

Low-pressure heating plant chimneys of moderate capacities may be taken from Table 3 or the curves in Fig. 1 with very satisfactory results.

According to their height, heating plant chimneys are divided into three classes, the erratic, uncertain and reliable. Chimneys less than 36 ft. high are erratic in their action. The head produced by such a low height

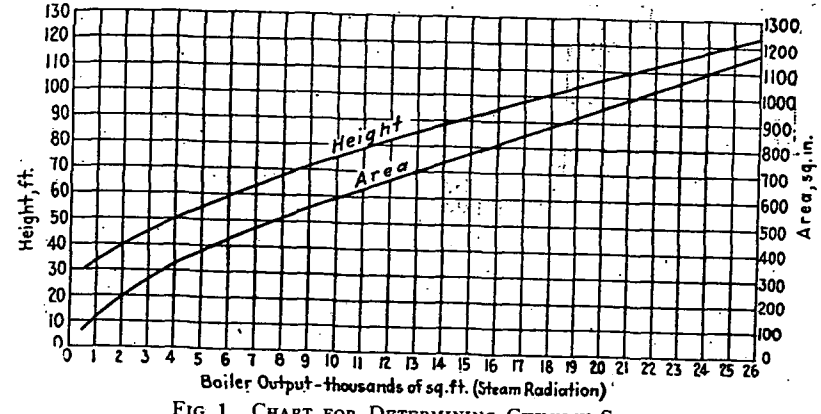


FIG. 1. CHART FOR DETERMINING CHIMNEY SIZE

Note 1.—It is impossible to make a rule for chimney dimensions which would apply to all boilers but it will be found that in general all heating boilers when burning any coal except smallest sizes will deliver more than the output shown at the bottom of the chart, Fig. 1, with the corresponding chimney dimensions, during the period when the boiler is likely to be in operation.

Note 2.—It is recommended that the manufacturer of the boiler be consulted in the case of exceptional boilers or where chimney dimensions are less than shown on chart for any given continuous output.

Note 3.—For battery installations the area of chimney is generally taken two-thirds to three-fourths the sum of the areas required for the same number of single boilers. The height is increased 5 to 15 ft. above the single boiler chimney height in order to compensate for additional turns and damper leakage.

Note 4.—Chimneys for oil-fired boilers may usually be taken 75 per cent of height and area of chimney for same output with solid fuel except that in cases where the possible change to coal is contemplated the chimneys should be selected as for solid fuel.

Note 5.—For gas-fired boilers the chimney dimensions may be selected from Fig. 1 but do not have to supply draft to move the products of combustion through the boiler or to supply air to the boiler. They serve only to remove the products of combustion from the boiler room. The draft diverter supplied with all gas boilers effectively limits the draft at the boiler outlet and also prevents a reversal of direction of flow in the chimney from effecting boiler operation.

is so small that the least unfavorable conditions or interference practically puts the chimney out of commission.

At best the head produced by chimneys up to 64 ft. in height is so small that the draft is frequently affected by surrounding conditions making the draft a doubtful one. Chimneys over 64 ft. in height are not usually so affected, because as a rule the chimney is designed by an

engineer and must be well built to sustain such a heavy load and the height is such as to produce considerable draft to offset unfavorable weather conditions, etc. Chimneys in this class produce about 0.00945 in. of theoretical draft per foot of height in zero weather with 600 deg. in the stack.

Chimneys recommended for larger boilers 15 to 250 hp. may be proportioned in accordance with the report made by a joint Committee of the

TABLE 3. CHIMNEY SIZES FOR LOW PRESSURE HEATING BOILERS AND WARM AIR FURNACES

Warm Air Furnace Capacity in Leader Pipe Sq. In.	Steam Boiler Capacity Sq. Ft. of Radiation	Hot Water Heater Capacity Sq. Ft. of Radiation	Nominal Dimensions of Fire Clay Lining In.	Rectangular Flue: Actual Inside Dimensions of Fire Clay Lining In.	Rectangular Flue: Actual Area Sq. In.	Rectangular Flue: Effective Area Sq. In.	Round Flue: Inside Diameter of Lining In.	Round Flue: Actual Area Sq. In.	Height in Ft. from Grate
790	590	973	8½x13	7x11½	81	70	10	79	As height necessary is dependent upon the draft requirements of the varying designs these factors should be known before height can be accurately determined.
1000	690	1140		11¼x11¼	127	99			
	900	1490	13x13	6¾x16¼	110	100	12	113	
	900	1490	8½x18						
	1100	1820		11¼x16¼	183	156	15	177	
	1700	2800	13x18						
	1940	3200		15¾x15¾	248	195			
	2130	3520	18x18	17¼x17¼	298	234	18	254	
	2480	4090	20x20				20	314	
	3150	5200							
	4300	7100							
	4600	7590	20x24	17x21	357	278			
	5000	8250	24x24	21x21	441				
	5570	9190		24x24*	576	380	22	380	
	5580	9200					24	452	
	6980	11500							
	7270	12000		24x28*	672	468			
	8700	14400		28x28*	784	531	27	573	
	9380	15500							
	10150	16750		30x30*	900	616			
	10470	17250		28x32*	896	635	30	707	
	11800	19500					33	855	
	14700	24300					36	1018	
	17900	29500							

*Dimensions below are for unlined rectangular flues.

American Boiler Manufacturers Association and *Stoker Manufacturers Association* and approved by these organizations. The sizes are given in Table 4.

Chimneys for Oil Fuel.[1]—The requirements for stacks for oil fuels are entirely different from those connected to coal-fired boilers, as there are certain losses through the boiler proper that are eliminated. Gas temperatures entering the stacks are lower for a given capacity, and the volume of gas is less than with coal. The cross-sectional area of the stack may therefore be less. In most instances this may safely be taken as

[1]From Marks' Mechanical Engineers Handbook.

60 per cent of the area that would be furnished for coal-fired boilers. In determining the height, care must be taken to design a stack that will give a sufficient draft for the maximum requirements of the boiler, but not more. In this way the efficiency is safeguarded, and the danger of a draft such as to pull through too large an excess of air is eliminated.

TABLE 4. HEIGHT OF STACK FOR AVERAGE INSTALLATIONS (Sea Level)

Average Draft Losses with Forced Draft Stokers

Per Cent Rating	100	150	200	250	300
Draft Furnace	0.15	0.15	0.15	0.15	0.15
Friction Loss (Boiler)	0.18	0.4	0.65	0.9	1.20
Friction Loss (Breeching)	0.10	0.10	0.10	0.10	0.10
Total Draft Required	0.43	0.65	0.90	1.15	1.45
Height of Stack (Ft.)	80	112	145	178	220

Diameter of Chimney in Inches for Horizontal Return Tubular Boilers				Height of Stack in Feet—For Sea Level and 60 deg. fahr. Outside Temp. Assumed Friction Loss in Stack 0.1 in. per 100 ft.			
Nominal H. P.	100% Rating	150% Rating	200% Rating	Draft at Base of Stack	100% Rating	150% Rating	200% Rating
15	13	14	17	0.12	21	22	25
20	14	16	18	0.15	26	28	30
25	16	18	20	0.20	35	37	41
30	17	19	21	0.25	43	46	51
35	18	20	22	0.30	52	56	61
40	19	21	23	0.35	60	65	71
50	20	23	25	0.40	69	74	81
60	21	24	27	0.45	78	84	91
75	23	26	29	0.50	86	93	101
90	25	28	31	0.55	95	102	111
100	26	29	33	0.60	104	112	122
115	27	31	34	0.65	112	121	132
125	28	32	35	.....	.....	.....	.....
150	30	34	38	.....	.....	.....	.....
175	32	36	40	.....	.....	.....	.....
200	33	38	43	.....	.....	.....	.....
210	34	38	44	.....	.....	.....	.....
225	35	40	45	.....	.....	.....	.....
250	36	41	47	.....	.....	.....	.....

DATA ON WHICH TABLES ARE BASED

Rating	100%	150%	200%	Stack Temp, deg. fahr.	450	500	550
Efficiency	65%	65%	63%				
CO_2	8%	9%	10%	Lbs. of Gas	85	77	73

Friction loss through boiler varies according to construction.
For Furnace Draft.—Allow 0.15 for forced draft. *For Natural Draft* 0.35 in. or higher should be used depending upon rate of combustion and fuel used.
For Breeching Friction Loss.—Allow 0.05 in. for each right angle bend and 0.1 in. per 100 ft. of length.

Chimneys for still greater horsepowers are given by Tables 5 and 6.

Table 7, adapted from one calculated by C. R. Weymouth (*Trans. A. S.M. E.*, Vol. 34, 1912) and based on actual test data, will be found to give satisfactory results under the assumed conditions as given for stacks with oil-burning boilers.

Table 5. Available Draft for 100 Ft. Steel Stacks of Different Diameters*
*(Based on a stack temperature of 500 deg. fahr.** and 100 lb. of gas per horsepower. For other heights of stack, multiply draft by height ÷ 100)*

Horsepower	Diameter of Stack in Inches														
	36	42	48	54	60	66	72	78	84	96	108	114	120	132	144
200	0.55	0.62													
400	0.21	0.46	0.56	0.61											
600		0.19	0.42	0.53	0.59										
800			0.23	0.43	0.52	0.58	0.61	0.63							
1000				0.29	0.45	0.53	0.58	0.61	0.63						
1200					0.35	0.47	0.54	0.58	0.61	0.64					
1600						0.31	0.43	0.52	0.56	0.62	0.64	0.65	0.65		
2000								0.43	0.50	0.59	0.62	0.63	0.64		
2500									0.41	0.54	0.60	0.61	0.63		
3000										0.48	0.56	0.59	0.61	0.63	0.64
3500										0.40	0.52	0.56	0.58	0.62	0.64
4000											0.48	0.52	0.56	0.60	0.62
4500											0.43	0.49	0.53	0.58	0.61
5000												0.44	0.49	0.56	0.60

*Data from Marks' Mechanical Engineers Handbook.
**For other stack temperatures add or deduct before multiplying by height ÷ 100, as follows:

For 750 deg. fahr. add 0.17 in. For 550 deg. fahr. add 0.04 in.
For 700 deg. fahr. add 0.14 in. For 450 deg. fahr. deduct 0.04 in.
For 650 deg. fahr. add 0.11 in. For 400 deg. fahr. deduct 0.09 in.
For 600 deg. fahr. add 0.08 in. For 350 deg. fahr. deduct 0.14 in.

Table 6. Stack Sizes by Kent's Formula
(Assuming 5 lb. of coal per horsepower per hour)

Diam. In.	Area Sq. Ft.	Height of Stack in Feet										Side of Equivalent Square Stack, Inches	Diam. Inches
		50	60	80	100	125	150	175	200	225	250		
		Commercial Horsepower											
33	5.94	106	115	133	149							30	33
36	7.07	129	141	163	182							32	36
39	8.30	155	169	196	219	245						35	39
42	9.62	183	200	231	258	289	316					38	42
48	12.57	246	269	311	348	389	426	460				43	48
54	15.90	318	348	402	449	503	551	595				48	54
60	19.64	400	437	505	565	632	692	748				54	60
66	23.76	490	537	620	694	776	849	918				59	66
72	28.27	591	646	747	835	934	1023	1105				64	72
78	33.18	700	766	885	990	1107	1212	1310				70	78
84	38.48	818	896	1035	1157	1294	1418	1531				75	84
90	44.18				1338	1496	1639	1770	1893	2008	2116	80	90
96	50.27				1532	1713	1876	2027	2167	2298	2423	86	96
102	56.75				1739	1944	2130	2300	2459	2609	2750	91	102
108	63.62				1959	2190	2392	2592	2770	2939	3098	98	108
114	70.88				2192	2451	2685	2900	3100	3288	3466	101	114
120	78.54				2438	2726	2986	3226	3448	3657	3855	107	120
126	86.59				2697	3016	3303	3568	3814	4046	4265	112	126
132	95.03				2970	3321	3637	3929	4200	4455	4696	117	132
144	113.10				3554	3973	4352	4701	5026	5331	5618	128	144
156	132.73				4190	4684	5131	5542	5925	6285	6624	138	156
168	153.94				4878	5454	5974	6454	6899	7318	7713	150	168

Loss of draft through the fuel bed or the force of draft necessary to burn different grades and sizes of coal at different rates of combustion may be taken from Fig. 1, p. 163 of Chapter VII on Mechanical Draft.

Table 7. Stack Sizes for Oil Fuel*

Stack Diameter Inches	Height in Feet Above Boiler Room Floor					
	80	90	100	120	140	160
33	161	206	233	270	306	315
36	208	253	295	331	363	387
39	251	303	343	399	488	467
42	295	359	403	474	521	557
48	399	486	551	645	713	760
54	519	634	720	847	933	1000
60	657	800	913	1073	1193	1280
66	813	993	1133	1333	1480	1593
72	980	1206	1373	1620	1807	1940
84	1373	1587	1933	2293	2560	2767
96	1833	2260	2587	3087	3453	3740
108	2367	2920	3347	4000	4483	4867
120	3060	3660	4207	5040	5660	6160

*Data from Marks' Mechanical Engineers Handbook.
Figures represent nominal rated horsepower; sizes as given are good for 50 per cent overloads. Based on centrally located stacks, short direct flues and ordinary operating efficiencies.

Correction for altitude may be made according to Table 8.

Table 8. Correction Factors for Altitude

Height Above Sea Level Feet	Ratio Increase in Diameter	Ratio Increase in Height
0	1.000	1.000
1,000	1.015	1.079
2,000	1.030	1.164
4,000	1.063	1.356
6,000	1.096	1.580
8,000	1.130	1.841
10,000	1.165	2.144

CHIMNEYS FOR GAS APPLIANCES

The burning of gas differs from the burning of coal in that the force which supplies the air for combustion of the gas comes largely from the pressure of the gas in the supply pipe, whereas air is supplied to a bed of burning coal by the force of the chimney draft. If, with a coal-burning boiler, the draft is poor, or if the chimney is stopped, the fire is smothered and the combustion rate reduced. Such a condition on a gas boiler or furnace would interfere with the combustion of the gas, but the gas would continue to pass to the burners and the resulting incomplete combustion would produce a dangerous condition. In order to prevent incomplete combustion from insufficient draft, all gas-fired boilers and furnaces should have a back draft diverter in the flue connection to the chimney.

A study of the drawing of a typical back draft diverter will make it plain that a stoppage in the chimney will cause the combustion products to come out into the boiler room, but there will be no interference with the complete combustion of the gas. Another feature in the construction of the back draft diverter is that a down draft from the chimney will have practically no effect upon the combustion of the gas, due to the baffle deflecting the draft into the boiler room.

As is the case with the complete combustion of almost all fuels, the product of combustion for gas are carbon dioxide (CO_2) and water vapor with just a trace of sulphur trioxide (SO_3). Sulphur usually burns to the trioxide in the presence of an iron oxide catalyst. The volume of water vapor in the flue products is about twice the volume of the carbon dioxide when coke oven or natural gas is burned. Because of the large quantity of water vapor which is formed by the burning of gas, it is quite important that all gas-fired central heating plants be connected to a chimney having a good draft. Lack of chimney draft causes stagnation of the products of combustion in the chimney and results in the condensation of a large amount of the water vapor. A good chimney draft draws air into the chimney through the openings in the back draft diverter, lowers the dew-point of the mixture, and reduces the tendency of the water vapor to condense.

Table 9. Minimum Round Chimney Diameters for Gas Appliances

Height of Chimney Feet	Gas Consumption in Thousands of B.t.u. per Hour								
	100	200	300	400	500	750	1000	1500	2000
20	4.50	5.70	6.60	7.30	8.00	9.40	10.50	12.35	13.85
40	4.25	5.50	6.40	7.10	7.80	9.15	10.25	12.10	13.55
60	4.10	5.35	6.20	6.90	7.60	8.90	10.00	11.85	13.25
80	4.00	5.20	6.00	6.70	7.35	8.65	9.75	11.50	12.85
100	3.90	5.00	5.90	6.50	7.20	8.40	9.40	11.00	12.40

A chimney for a gas-fired boiler or furnace should be constructed in accordance with the principles applicable to other boilers. Where the wall forming a smoke flue is made up of less than an 8 in. thickness of brick, concrete or stone, a burnt fire clay flue tile lining should be used. Care should be used that the lengths of flue tile meet properly with no openings at the joints. Cement mortar should be used for the entire chimney.

The accompanying table gives the minimum cross-sectional areas of round chimneys (in square inches) for various amounts of heat supplied to the appliance, and for various chimney heights. This is in accordance with *American Gas Association* recommendations.

The flue connections from a gas-fired boiler or furnace to the chimney should be of a non-corrosive material. In localities where the price of gas requires the use of highly efficient appliances, the material used for the flue connection not only should be resistant to the corrosion of water, but should resist the corrosion of dilute solutions of sulphur trioxide in water. Sheet aluminum, as well as some other materials, seems to serve this purpose very well.

CONSTRUCTION OF CHIMNEYS

For general data on the construction of chimneys reference should be made to the Standard Ordinance for Chimney Construction of the National Board of Fire Underwriters. Briefly summarized these provisions are as follows for heating boilers and furnaces:

The construction, location, height and area of the chimney to which a heating boiler or warm-air furnace is connected affect the operation of the entire heating system. Most residence chimneys are built of brick and may be either lined or unlined, but in either case the *walls must be air-tight* and there should be *only one smoke opening* into the chimney. Cleanout, if provided, must be *absolutely air-tight* when closed.

The walls of brick chimneys shall be not less than 3¾ in. thick (width of a standard size brick) and shall be lined with fire-clay flue lining. Fire-clay flue linings shall be manufactured from suitable refractory clay, either natural or compounded, and shall be adapted to withstand high temperatures and the action of flue gases. They shall be of standard commercial thickness but not less than ¾ in. All fire-clay flue linings shall meet the standard specification of the *Eastern Clay Products Association*. The flue sections shall be set in special mortar, and shall have the joints struck smooth on the inside. The masonry shall be built around each section of lining as it is placed, and all spaces between masonry and linings shall be completely filled with mortar. No broken flue lining shall be used. Flue linings shall start at least 4 in. below the bottom of smoke-pipe intakes of flues, and shall be continued the entire heights of the flues and project at least 4 in. above chimney top to allow for a 2 in. projection of lining. The wash or splay shall be formed of a rich cement mortar. To improve the draft the wash surface should be concave wherever practical.

Flue lining may be omitted in brick chimneys, provided the walls of the chimneys are not less than 8 in. thick, and that the inner course shall be a refractory clay brick. All brickwork shall be laid in spread mortar, with all joints push-filled. Exposed joints both inside and outside shall be struck smooth. No plaster lining shall be permitted.

Chimneys shall extend at least 3 ft. above flat roofs and 2 ft. above the ridges of peak roofs when such flat roofs or peaks are within 30 ft. of the chimney. The chimney shall be high enough so that the wind from any direction shall not strike the top of the chimney from an angle above the horizontal. The chimney shall be properly capped with stone, terra cotta, concrete, cast iron, or other approved material; but no such cap or coping shall decrease the flue area.

There shall be but one connection to the flue to which the

boiler or furnace smoke-pipe is attached. The boiler or furnace smoke-pipe shall be thoroughly grouted into the chimney and shall not project beyond the inner surface of the flue lining.

The size or area of flue lining or of brick flue for warm-air furnaces depends on height of chimney and capacity of heating system. For chimneys not less than 35 ft. in height above grate line, the net internal dimensions of lining should be at least 7 x 11½ in. for a total leader pipe area up to 790 sq. in. Above 790 and up to 1000 sq. in. of leader pipe area the lining should be at least 11¼ x 11¼ in. inside. In case of brick flues not less than 35 ft. in height with no linings, the internal dimensions should be at least 8 x 12 in. up to 790 sq. in. of leader area, and at least 12 x 12 in. for leader capacities up to 1000 sq. in. Chimneys under 35 ft. in height are unsatisfactory in operation and hence should be avoided.

SMOKE TEST

The chimney flue shall be subjected to a smoke test by the mason contractor in the presence of the architect or his representative, after the mortar has thoroughly hardened, and must be *smoke tight*.

The method of conducting this test shall be as follows: With a good fire in the boiler or furnace, or in the base of the chimney, put about a square yard of tar paper on the fire. As soon as smoke appears at the top of the chimney close the top of the flue with a piece of old carpet or wet newspapers held down by a weighted board. Keep the tar paper burning in the firepot for five minutes. The architect or his representative shall sign an acceptance in triplicate, stating that the chimney was tight under the above test, and shall give one copy to the mason contractor, one copy to the heating contractor and one copy to the owner.

CHAPTER VII

MECHANICAL DRAFT

Data on Grates, Forced Draft, Induced Draft, Motor Driven Blowers, Steam Driven Blowers, Steam Jets, Stokers, Duct Work.

THE subject of mechanical draft is divided into two main divisions—forced draft and induced draft. Present day practice inclines towards forced draft for heating plants. The burning of the lower grades and the smaller sizes of coal necessitates strong drafts, which are frequently produced mechanically. The stack or chimney effect necessary to properly carry off the gases of combustion is sometimes produced by induced draft. With the type of installations considered in this chapter which relate particularly to the heating and ventilating field, forced draft installations predominate. The combination of both forced and induced draft is sometimes employed, but is usually confined to power stations where economizers, air heaters, etc. are installed.

In order to give proper recommendations for mechanical draft, something should be said about the grates and furnaces. Table 1 gives the various styles of grates suitable for different fuels in boiler plants mentioned in this article.

TABLE 1. GRATES SUITABLE FOR VARIOUS FUELS AND BOILERS

KIND OF FUEL	HIGH PRESSURE BOILERS	HIGH OR LOW PRESSURE STEEL BOILERS—FIRE BOX	LOW PRESSURE CAST IRON SECTIONAL	HIGH OR LOW PRESSURE SCOTCH MARINE	HIGH OR LOW PRESSURE UPRIGHT	TYPE OF AIR OPENINGS AND % OPENINGS
Domestic Anthracite	Stationary or Shaking	Shaking	Shaking	Shaking	Shaking	Herringbone Finger or Cross Rib 30% – 40%
No. 1 Buckwheat	Stationary or Dumping	Dumping	Dumping	Stationary or Dumping	Stationary Shaking or Dumping	Fine Herringbone Slotted or Pinhole 8% – 14%
No. 2 Buckwheat	Stationary or Dumping	Dumping	Dumping	Stationary or Dumping	Stationary or Dumping	Fine Slotted or Pinhole 8% – 12%
No. 3 Buckwheat Screenings	Stationary or Dumping	Dumping	Dumping	Stationary or Dumping	Stationary or Dumping	Fine Slotted or Pinhole 8% – 10%
Run of Mine Bituminous	Stationary or Shaking	Shaking	Shaking	Stationary or Shaking	Stationary or Shaking	Herringbone or Cross Rib 30% – 40%

The material for this Chapter prepared especially for THE GUIDE by R. W. Pryor, Edgar Johnson and C. H. Smith.

STATIONARY GRATES

Stationary grates are installed on bearing bars, and not movable except as they are lifted out of the furnace for repair or replacement. Such grates are made in a large assortment of shapes, sizes, weights and have varying percentage of air openings. They may be air cooled or water cooled, for use under natural or mechanical draft and may be used with practically all kinds of hand fired fuels. Cleaning of fires must be done through firing doors. This makes it advisable for the grates to be at the firing door level. In cleaning fires, it is necessary to "wing" or jump the ashes over the live char.

SHAKING GRATES

This type of grate is used where it is desired to accomplish the removal of the ash or fuel refuse by shaking, rocking, or a rolling motion of each grate bar unit. This operation can be performed at any time and under any fire condition and with any fuel which will not fall through the grate during the shaking process. It is essentially an open type grate with a large percentage of air opening and is used to best advantage under fuels that coke or bridge and that burn to a fine ash. Domestic sizes of anthracite, wood refuse, hogged fuel, bagasse, lignite, run-of-mine bituminous, etc., are types of fuels suitable for burning on shaking grates.

DUMPING GRATES

The fine sizes of fuels such as the Buckwheat sizes of anthracite, mine or coal yard screenings, hard-wood sawdust and coke braize are burned to advantage on dumping grates. These fuels require keeping the fires level and adding fuel over the entire surface of the fire bed, continuing this procedure until cleaning time, i.e., until the mass of ashes and burning fuel reaches a thickness which prevents adequate supply or proper diffusion of air, or becomes too high for proper spreading.

Ash accumulation under such firing cannot well be removed by shaking for the reason that the fire bed becomes uneven in thickness and openings large enough to permit the ash to pass through would also allow unburned fuel to pass to the ashpit. This explains the difference between *shaking* and *dumping* grates.

Dumping grates are built in sections enabling the operator to push the unburned fuel off the ash bed to another section. The accumulated ash is then dumped into the ashpit and the live char from another section is pulled over onto the clean section of the grate. After this process has been continued until all of the ashes have been dumped, the live char should be allowed to burn down before covering with fresh fuel in order to prevent the formation of clinkers on the fresh fire. Where blowers are in use or the boiler is operating under strong natural draft, fuel should not be added to a freshly cleaned fire until the formation of ash on the surface of the grate has begun, for ash is a good diffuser of air and in addition protects the surface of the grates from overheating. The first firing should be thin and evenly spread over the entire fire bed and allowed to burn down after which successive firings can be made heavier.

This will form a formidable ash foundation after which it is practically impossible to form a hard clinker, even though fuels with very low fusing ash are used.

MECHANICAL STOKERS

Three types of stokers are commonly used, namely chain-grate, under-feed and over-feed type. Their use permits a uniform fuel supply, efficient combustion, boiler operation at higher rating and the effectual meeting of peak loads. Either forced or induced draft is successful with chain grate stokers which are designed primarily for the use of bituminous coal particularly the free burning and clinkering types. Where forced draft is used, air is delivered at different pressures under the grate, the control being accomplished by dampers, to suit the grade of fuel and the firing rate. At the front the pressure will not exceed 2 in. water gage and will decrease toward the rear as the fuel bed gets thinner.

There are adaptations of self-feeding devices especially adaptable to the smaller heating plants which carry forced draft apparatus, controlled as outlined herein under forced draft. Some of these take the form of a hopper which feeds the coal through tuyeres and automatically brings the ash out of the ashpit. Others take the form of an under-feed type of stoker, which has a variable feed depending upon the heating requirements. There are adaptations of chain-grate stokers which emulate the more pretentious power type of units, all of which have their particular field for the kind of fuel to be burned and function as a labor saving device, but all in general follow principles as outlined in the foregoing treatise.

Over-feed stokers are adapted for all kinds of fuel and the angle of the grate bars will indicate whether bituminous, semi-bituminous, coking coal or the non-coking types are to be used.

Under-feed stokers are made in single or multiple units and will burn coking or non-coking varieties of coal equally well. In both cases either forced or induced draft may be used.

The important points to be observed in recommending and using stoker installations are:

1. Stokers in large plants used in conjunction with modern methods of coal storage and handling at their disposal show a considerable labor saving.
2. In small plants stokers are only advisable where the saving in fuel will be large or where the smoke question is a factor.
3. The upkeep cost of stokers generally exceeds that for hand fired furnaces.
4. The use of different fuels and a better efficiency is obtainable with mechanical stokers.

No stoker will handle every class of fuel satisfactorily so that in selecting a stoker the engineer should take into consideration the type best suited for the fuel and operating conditions. Relative to efficiency of combustion, other conditions being similar, there will be no appreciable difference with the different types of stokers provided that the proper type is used for the fuel to be burned and the operating conditions are fulfilled.

THE STACK

The function of the stack under natural draft operation is threefold: (1) to eliminate the waste gases; (2) to circulate the hot gases through the heating surfaces of the boiler and (3) to draw the air, necessary for combustion, through the fuel bed. The fuel bed resistance varies with the type of fuel and the last function referred to, becomes the heaviest stack load on the finer grades of fuel and this load is applied at the point where the stack is least able to handle it. Increasing the stack pull to the point where sufficient air can be drawn through a heavy bed of fine fuel results in a waste of heat due to excess air and a tendency to lift a certain amount of unconsumed fuel, unless the draft be properly controlled, by dampers, according to the varying thicknesses of the fuel bed.

The draft from stacks also varies according to temperatures and wind conditions. This, coupled with the difficulties of control referred to above frequently brings up the question of using properly regulated mechanical draft.

MECHANICAL DRAFT

There is a certain draft which will give the best results for every kind of fuel and rate of combustion. The amount of fuel that can be burned per hour per square foot of grate surface is governed by the quality and the type of fuel as well as by the draft obtainable.

Mechanical draft is used to obtain economy of operation, increased capacity or both and may be accomplished by either the forced or induced method. The two common methods of producing mechanical draft are by means of fans or steam jets. Each method has its advantages and design conditions will govern the choice of apparatus.

Mechanical draft fans are usually either disc or centrifugal type and because of the severe service to which they are subjected they must be of rugged construction, well balanced, must be able to operate continuously, withstand high stresses, maintain the proper pressure and horse-power characteristics and show a good efficiency over a wide range of operating conditions.

Mechanical draft fans should be of such capacity that they will be able to handle the quantity of gases produced. If it is assumed that 5 lb. of coal per boiler horsepower at 24 lb. of flue gases per pound of coal there would be 120 lb. of flue gases per hour to handle.

The volume of flue gases may be easily computed from the density of gases at the room temperature for forced draft and at flue temperature for induced draft and the size of fan to be provided may be obtained from the fan maker's table.

Fig. 1 shows the difference in pressure required between the ashpit and the furnace in order to burn various classes of fuel at different rates on the grate.

FORCED DRAFT

This is usually applied by what is known as the direct method where air is piped directly to the ashpit through intervening duct work with a pressure maintained sufficient to force the air through the necessary duct system, stoker setting if installed, and the fuel bed. Excessive pressures

not only create an outrush of flame and smoke when fire doors are opened but also cause objectionable leakage of gases into the boiler room.

For best firing condition, a slight indraft of 0.05 in. to 0.10 in. of water should be maintained above the fire and the remaining losses through the boiler, breeching, etc. should be taken care of by the stack or induced draft fan.

The determining factors for the correct amount of air and static pressure for forced draft installations are: the boiler rating to be developed, grate area and kind of fuel to be used.

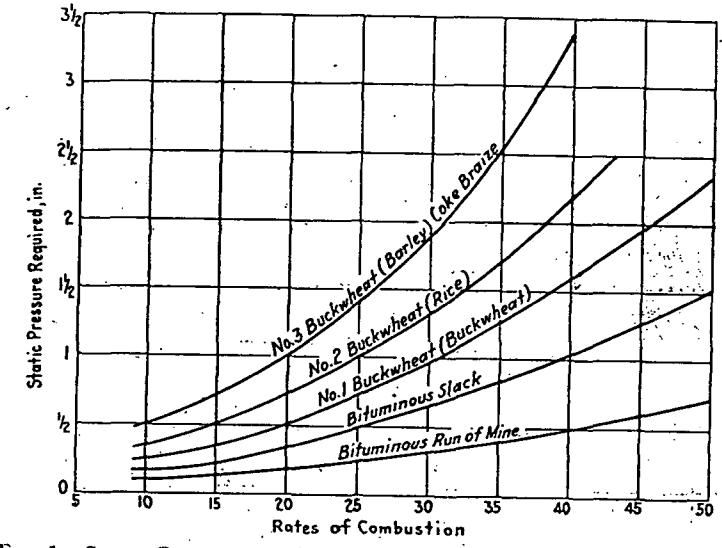


Fig. 1. Static Pressures Required to Burn Various Fuels at Various Rates of Combustion

For example:—On a 200 hp. boiler at 150 per cent rating with 45 sq. ft. of grate surface and using buckwheat coal it is found that by using 20 c.f.m. per hp. which would provide about 100 per cent excess air (a proper selection for hand fired conditions) 6000 c.f.m. would be required. Basing the calculations on 4½ lb. of coal per hp. developed would give 1350 lb. of coal fired per hour or 30 lb. of coal per square foot of grate per hour.

From Fig. 1 it will be noted that No. 1 Buckwheat would require 1 in. static pressure, and Barley, 2 in. static pressure. To this must be added the duct losses. The accompanying Table 2, gives the various velocities desirable for such an installation.

With low pressure heating boilers such as the steel firebox type and cast iron sectional boilers, observations show that 15 lb. of coal per hour per square foot of grate surface for the former and 10 lb. for the latter are reliable rates for burning.

TABLE 2. AIR DUCT VELOCITIES FOR FORCED DRAFT

STATIC PRESSURES	VELOCITY IN MAIN AIR DUCT 5 PER CENT STATIC PRESSURE	VELOCITY IN MAIN AIR DUCT 10 PER CENT STATIC PRESSURE
2	1300	1800
2½	1400	2000
3	1550	2200
3½	1700	2400
4	1800	2550
4½	1900	2700
5	2000	2850
5½	2100	3000
6	2200	3100
6½	2300	3250
7	2400	3350

From *Recommendations for the Installation of Stoker Fans* by the Stoker and Fan Manufacturers' Association:

The area of the main air ducts shall be determined by using a velocity in the ducts based on a velocity pressure of from 5 per cent to a maximum of 10 per cent of the static pressure.

The area of the branch air ducts leading to boilers should be such that the velocity will not be more than two-thirds of that in the main ducts.

The above table is based on a weight of air of 0.075 lb. per cu. ft. which corresponds to a temperature of 68 deg. fahr., a barometric pressure 29.92 in. (sea level) and 50 per cent relative humidity. (For higher elevations or temperatures, the above velocities may be increased 1 per cent for each 500 ft. increase in elevation, add 1 per cent for each 10 deg. fahr. increase in temperature.)

It is desirable to have the duct work as short and straight as possible and for the class of installations contemplated under this heading 2500 ft. per minute is a satisfactory velocity for the air through the duct work as a maximum.

TABLE 3. FOR FORCED DRAFT BLOWERS

Based on 40 cu. ft. of air per minute per square foot of grate

	No. 1 Buckwheat Coal					No. 2 and 3 Buckwheat Coal				
Grate Area Sq. Ft.	Size of Blower Outlet In.	C.f.m.	Static Press. In.	Motor Hp.	Speed R.p.m.	Size of Blower Outlet In.	C.f.m.	Press. In.	Motor Hp.	Speed R.p.m.
4	4	160	0.25	1/15	1750	....	.....	.....	.....	.....
6	6	240	0.51	1/6	1150	....	.....	.....	.....	.....
10	6	400	0.75	¼	1750	8	400	1.14	½	1750
12	6	480	0.68	¼	1750	9	550	1.23	½	1750
16	8	700	0.76	⅓	1750	9	700	1.04	½	1750
20	9	800	0.91	½	1750	8	800	1.25	¾	1750
24	9	960	0.65	½	1750	9	960	1.22	¾	1750
30	9	1200	0.93	¾	1750	12	1300	1.25	¾	1150
36	11	1440	0.72	½	1150	....	.....	.....	.....	.....
40	9	1600	1.2	1½	1750	9	1600	1.22	1½	1750

TABLE 4. CAPACITIES AND DIMENSIONS OF PROPELLER TYPE FORCED DRAFT BLOWERS

Outside Diameter of Fan Housing Inches	Motor H.P.	Cubic Feet per Minute at Various Static Pressures						
		0.10″	0.15″	0.20″	0.25″	0.50″	0.75″	1.00″
12	⅛	1100	1050	950	850	300	.....	.....
14	¼	1600	1550	1500	1450	750	450	.....
16	½	2550	2450	2350	2250	1450	1100	800
18	¾	3300	3250	3200	3150	2800	2300	1500
21	1	4350	4250	4150	4050	3500	2750	2000
24	1½	6300	6200	6100	6000	5500	4900	4100
27	2	8400	8300	8200	8100	7500	6800	6100

TABLE 5. CAPACITIES AND DIMENSIONS OF STEAM TURBINE DRIVEN PROPELLER TYPE FORCED DRAFT FANS

Outside Diameter of Fan Housing Inches	R.P.M.	Cubic Feet per Minute at Various Static Pressures									
		0.25″	0.50″	0.75″	1.00″	1.25″	1.50″	1.75″	2.00″	2.50″	3.00″
16	4000	3200	3050	2900	2800	2650	2450	2200	1950	.....	.....
	5000	4100	4000	3850	3700	3600	3450	3300	3100	2700	2100
18	3600	5350	5150	4950	4700	4400	4000	3650	3300	2650	.....
	4500	7000	6800	6600	6450	6250	6050	5800	5600	5100	4550
18	3800	5700	5550	5350	5100	4850	4600	4300	4000	3300	.....
	4700	7300	7150	7000	6800	6600	6450	6250	6000	5600	5000
21	3400	6350	6150	5950	5700	5450	5150	4800	4400	3550	.....
	4000	7550	7400	7250	7100	6850	6600	6400	6100	5500	4700
21	3600	6700	6570	6400	6250	5950	5700	5400	5050	4250	3450
	4500	8400	8350	8250	8100	8000	7800	7600	7350	6850	6200
22	3300	7800	7550	7300	7000	6700	6400	6050	5700	5000	4000
	4100	9900	9700	9450	9200	9000	8700	8400	8150	7500	6900
22	3500	8800	8050	7800	7500	7250	6950	6650	6350	5700	4850
	4300	10300	10050	9850	9650	9450	9250	9000	8750	8200	7600
25	3100	9700	9450	9150	8800	8500	8100	7800	7400	6650	5900
	3600	11350	11200	10850	10650	10400	10000	9750	9500	8850	8150
25	3400	10700	10450	10150	9850	9500	9150	8850	8500	7900	7250
	4200	13000	12800	12600	12300	12200	11950	11700	11450	10900	10350
29	3200	15100	14800	14300	14000	13500	13000	12500	11700	10700	9600
	3800	18200	17800	17500	17100	16800	16500	16100	15600	14500	13600
32	3200	18400	18250	18100	17900	17650	17350	17050	16750	16000	15000
	3600	20500	20400	20300	20200	20000	19800	19550	19400	18900	18200

The majority of installations today are using the motor driven forced draft blowers of the direct connected type. The variable speed type permits of a flexible control over the fires. A regulating device conveniently located at the boiler front can be adjusted from time to time to correspond to the prevailing thickness of fire bed rather than have the fireman go some distance to adjust the draft.

Enclosed types of motors are preferable, in order to reduce the wear on the bearings and brushes.

Where high pressure steam is available, there is an advantage in either steam engine or turbine driven units, if the exhaust steam can be led into the feed water heaters or steam heating system.

Forced draft blowers may be put in individually, one for each boiler or in multiples. The controlling of the motors may be either manual or automatic. In the case of the latter a pressure regulator from the main steam header is connected electrically in relay to a magnetic switch of sufficient capacity to carry the forced draft unit.

For small forced draft installations using the fine grades of Buckwheat coal, this applies more particularly to house heating, schools, etc., the accompanying Table 3 (based on 40 c.f.m. per square foot of grate) and Tables 4 and 5 are convenient to use.

A satisfactory arrangement, for such units, is to connect the blower discharge to the ashpit by means of a blast gate and control it in parallel with the stack damper. A room thermostat, preferably placed in the living quarters regulates the blast of air by cutting in and out the blower simultaneously as the thermostat calls for more or less heat from the boiler. In order to compensate for the time element between the generation of heat in the boiler and its delivery to the radiation in the living quarters, there should be a device such as a pressurestat or aquastat on the boiler proper in order to limit the top pressure or temperature of the boiler by cutting out the blower when it reaches that limit irrespective of the room thermostat referred to previously.

INDUCED DRAFT

Induced draft may be used where the stack, boiler and furnace resistance are such that the average stack becomes overloaded for a given rating on the boiler. The induced draft fan might then be placed near the base of the stack for handling smoke and gases leaving the furnace, whereupon a high stack would not be needed, the necessary draft being created by the fan. Induced draft fans should not create an excessive vacuum through the fuel bed as this increases the air leakage through the breeching and stack causing unnecessary heat loss. In the larger boiler plants where economizers and air preheaters are used, the duty placed upon the chimney becomes very great and, particularly where boilers are being operated at a high percentage of over rating, the induced draft fan becomes a desirable part of the plant equipment. The induced draft fan has to handle a large volume of air at a high temperature and for stack gas at 550 deg. temperature which is an average figure, there will be required approximately 40 cu. ft. per minute per boiler hp. to be handled, allowing 100 per cent excess air for hand fired installations. In case of stoker fired furnaces not over 50 per cent excess air is calculated.

CHAPTER VIII

GRAVITY WARM-AIR FURNACE HEATING

Data on Furnaces, Leader Sizes, Stack Sizes, Air Temperatures, Register Sizes and Locations, Recirculation, Layouts, Standard Installation Code.

HEATING WITH AIR

THERE are several typical systems of warm-air heating in common use today. An analysis of the systems mentioned in the following list will show that warm air may be employed as the heating medium in almost all types of heating requirements: (1) Gravity warm-air furnace systems, with or without booster fans for forced circulation and combination air and water systems for isolated rooms; (2) Fan-furnace heating systems (see Chapter IX); (3) Fan-blast heating systems (see Chapter X); (4) Unit heating systems (see Chapter X); (5) Indirect radiation systems (see Chapter II).

Each system has its particular application: No. 1 is intended particularly for residences and small structures; No. 2 for large residences, small theatres, churches, schools and stores; No. 3 for large buildings, theatres, schools, churches and factories; No. 4 for shops, factories and other large enclosures and No. 5 for homes, hotels, schools, etc.

In this chapter of THE GUIDE, consideration will be given to the design of gravity circulating warm-air heating systems. For fan circulating systems see Chapters IX, X, XXIV, XXV and XXVIII. Complete engineering data, including the procedure to be followed in designing a typical system, are presented in the first part of this chapter, while the last part of the chapter presents a Standard Code Regulating the Installation of Gravity Warm-Air Heating Systems in Residences, approved by the *National Warm Air Heating Association*, AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS and the *National Association Sheet Metal Contractors*, as a workable Code for furnacemen.

DEFINITIONS

In general, warm-air furnace heating plants consist of a fuel burning furnace or heater enclosed in a casing of sheet metal or brick, which is placed in the basement of the building. The heated air, taken from the

---

For this edition the chapter has been revised and edited by Prof. J. D. Hoffman, Director of Practical Mechanics Laboratory, Purdue University.

Material for this section was originally prepared for THE GUIDE by A. C. Willard, Professor of Heating and Ventilation and Head of the Department of Mechanical Engineering, University of Illinois, Urbana, Illinois.

All figures and much of the engineering data which follow are from Bulletin No. 141, "Warm Air Furnaces and Heating Systems," Part II, by Professors A. C. Willard, A. P. Kratz and V. S. Day, Engineering Experiment Station, University of Illinois.

top or sides near the top of the furnace casing, is distributed to the various rooms of the building through sheet metal warm-air pipes. The warm-air pipes in the basement are known as leaders, and the vertical warm-air pipes which are run in the inside partitions of the building are called stacks. The heated air is finally discharged into the rooms through

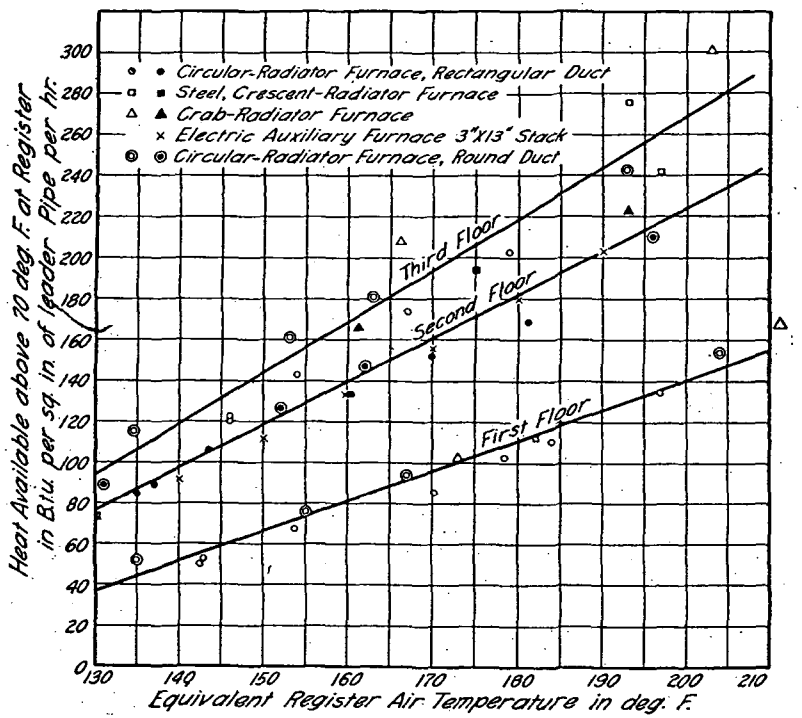


FIG. 1. VALUE OF SQUARE INCH OF LEADER PIPE AREA FOR FIRST, SECOND, AND THIRD FLOORS

registers which are set in register boxes placed either in the floor or in the side wall, usually at or near the baseboard.

The air supply to the furnace may be taken (1) entirely from inside the building through one or more recirculating ducts, (2) entirely from outside the building, in which case no air is recirculated, or (3) through a combination of the inside and outside air supply system is employed.

Furnace heating plants may be (1) of the gravity circulating type in which the motive head producing flow depends upon the difference in weight between the heated air leaving the casing and pipes and the cooler air entering the bottom of the casing, or (2) of the fan circulating type in which a fan may supply all or part of the motive head producing flow. In most house installations, the former type of system is in general use.

DESIGNING A FURNACE HEATING SYSTEM

The design of a furnace heating system involves the determination of the following items:

a. Heat loss in B.t.u. from each room in the building.

b. Area and diameter in inches of warm-air pipes in basement (known as leaders).

c. Area and dimensions in inches of vertical pipes (known as wall stacks).

d. Free and gross area and dimensions in inches of warm-air registers.

e. Area and dimensions of (1) recirculating or (2) outside air supply ducts in inches. There may be one or more of each.

f. Free and gross area and dimensions in inches of recirculating registers.

g. Size of furnace necessary to supply the warm air required to overcome the heat loss from the building. This "size" should include square inches of leader pipe area which furnace must supply. It is also desirable to call for a minimum bottom fire-pot diameter in inches, which is the nominal grate diameter.

h. Area and dimensions in inches of chimney lining and smoke pipe. If an unlined chimney is to be used, that fact should be made clear.

HEAT LOSSES FROM BUILDING

The heat which will be required for each room in the building depends on (1) the heat transmission losses through walls and glass as well as through floors and ceilings when the latter two are next to unheated spaces, and (2) the infiltration of cold air through the cracks around outside windows and doors. Calculations for the heat required in B.t.u. per hour should be made as indicated in Chapter I, Heat Losses from Buildings.

LEADER SIZES

In a gravity circulating warm-air furnace system the size of the leader to a given room depends on the temperature of the warm air entering the room at the register. A reasonable air temperature at the registers must, therefore, be agreed upon before the system can be designed. The *National Warm Air Heating Association* has approved an air temperature of 175 deg. fahr. at the registers as satisfactory. At this temperature, the heat carrying capacity (heat available above 70 deg. fahr.) per square inch of leader pipe per hour for first, second or third floors is shown by Fig. 1 at 175 deg. fahr. to be 105, 170 and 208 B.t.u. respectively. For average calculations, the values 111, 166 and 200 will simplify the work and may be satisfactorily substituted for these heat carrying capacities. If H represents the total heat to be supplied any room, the resulting equations are:

$$\text{Leader areas for first floor, square inches} = \frac{H}{111} = \text{approximately } 0.009H \quad (1)$$

$$\text{Leader areas for second floor, square inches} = \frac{H}{166} = \text{approximately } 0.006H \quad (2)$$

$$\text{Leader areas for third floor, square inches} = \frac{H}{200} = \text{approximately } 0.005H \quad (3)$$

In designing for a lower warm-air register temperature, say 160 deg. fahr., the factors 111, 166 and 200 become 80, 140 and 166 (Fig. 1 at 160 deg. fahr.), and the resulting equations are:

$$\text{Leader areas for first floor, square inches} = \frac{H}{80} = \text{approximately } 0.012H \qquad (4)$$

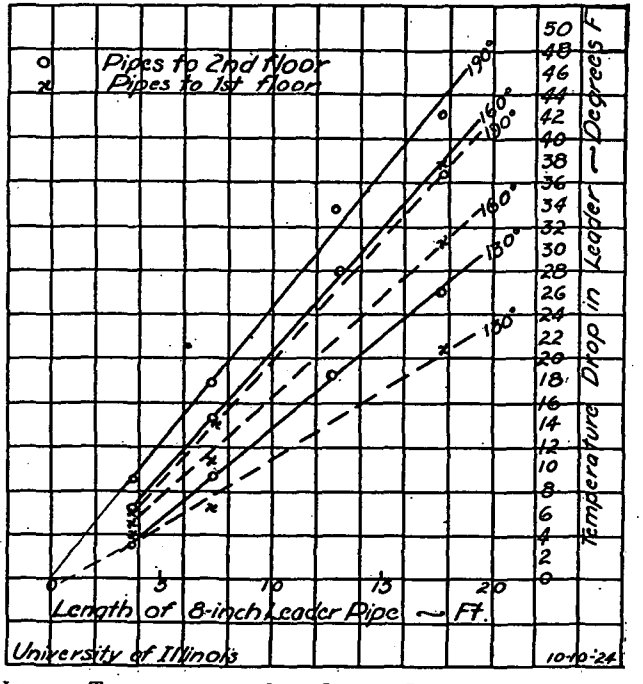


FIG. 2. LOSS IN TEMPERATURE IN 8 IN. LEADER PIPE OF VARIOUS LENGTHS AT DIFFERENT REGISTER TEMPERATURES

$$\text{Leader areas for second floor, square inches} = \frac{H}{140} = \text{approximately } 0.007H \qquad (5)$$

$$\text{Leader areas for third floor, square inches} = \frac{H}{166} = \text{approximately } 0.006H \qquad (6)$$

These equations are applicable to straight leaders from 6 to 8 ft. in length. Longer leaders must be very thoroughly covered or else the vertical stacks must be increased in area as discussed under wall stacks. If some provision is not made for these longer leaders, the air temperature may be much lower than anticipated and the room will not be properly heated.

While Fig. 1 takes care of the drop of temperature in straight leaders up to 8 ft. in length connected to stacks having about 75 per cent the area of the leader, the designer must make allowances for all other

conditions. The temperature drop in leaders of various lengths at three different register temperatures is shown in Fig. 2.

Leader sizes should in general be not less than obtained by equations (1) to (3) nor should leaders less than 8 in. in diameter be used. It is not considered good commercial practice to specify diameters except

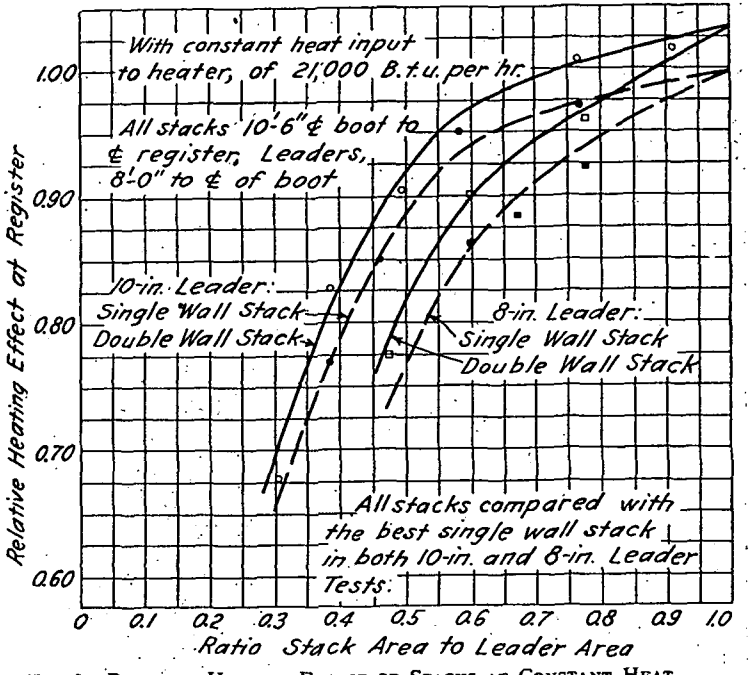


FIG. 3. RELATIVE HEATING EFFECT OF STACKS AT CONSTANT HEAT INPUT TO FURNACE

Note.—Pipe bare, bright tin except asbestos strips for joints.

in whole inches, although there is no real reason for not using half inches if necessary. The tops of leaders should be at the same elevation as they leave the furnace bonnet, and from this point there should be a uniform up-grade of 1 in. per foot of run in all cases. Leaders over 12 ft. in length are to be avoided or receive very special attention.

WALL STACKS

The wall stack for an upper floor should be made not less than 70 per cent of the area of the leader which has been selected from Fig. 1. So long as the leader is short and straight as was the case for Fig. 1, such a practice is probably justified since the loss (Fig. 3) in capacity occasioned by the smaller stack is not very serious for stacks having areas in excess of 70 per cent of the leader area. For leaders over 8 ft.

in length or for leaders which are not straight, the ratio of stack area to leader area should be greater than 70 per cent in order to offset the

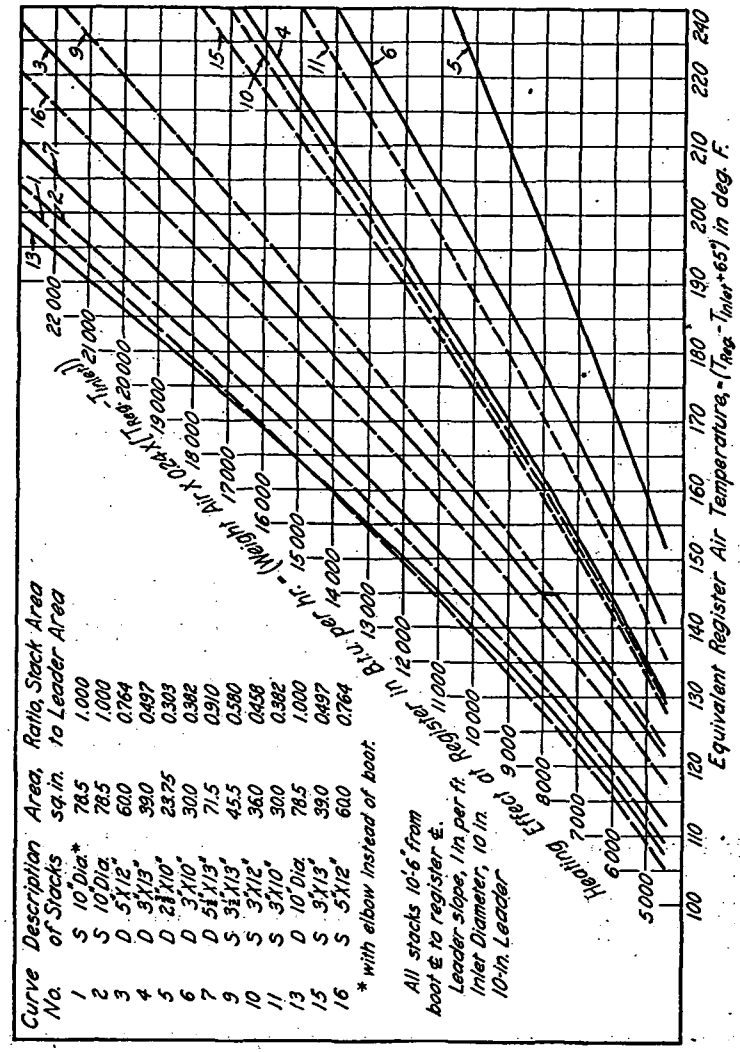


FIG. 4. HEATING EFFECT AT REGISTERS FOR VARIOUS STACKS WITH 10-INCH LEADER

greater temperature losses (Fig. 2) in the longer leader. In gravity circulating systems, this stack to leader area ratio is a very important consideration. Specific data for a great variety of cases are presented in Figs. 4 and 5 and the designer should check his stack to leader com-

binations with the nearest comparable case as shown in these figures. Any second floor stack supplying heat to a room whose heat loss is 9000

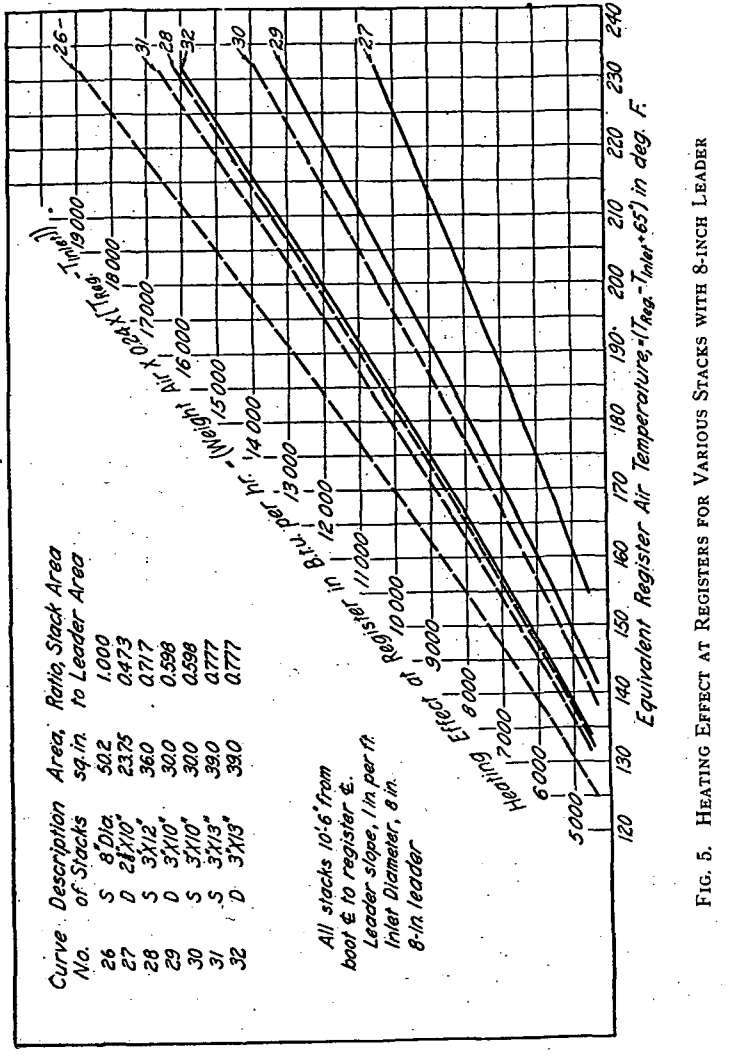


FIG. 5. HEATING EFFECT AT REGISTERS FOR VARIOUS STACKS WITH 8-INCH LEADER

B.t.u or above (see Figs. 4 and 5 which show that high temperatures are necessary if rooms of more than 9000 B.t.u. requirement are heated by stacks in 4-in. studding), should be run within 6-in. studded walls or should have multiple stacks. Stack sections, wherever possible, should

be changed from the thin rectangular to the more nearly square shape. Stack heads should have upper end curved to provide easy flow of warm air to the room.

WARM-AIR REGISTERS

The registers used for discharging warm air into the rooms should have free or net area not less than the area of the leader in the same run of piping. The free area should be at least 70 per cent of the gross area

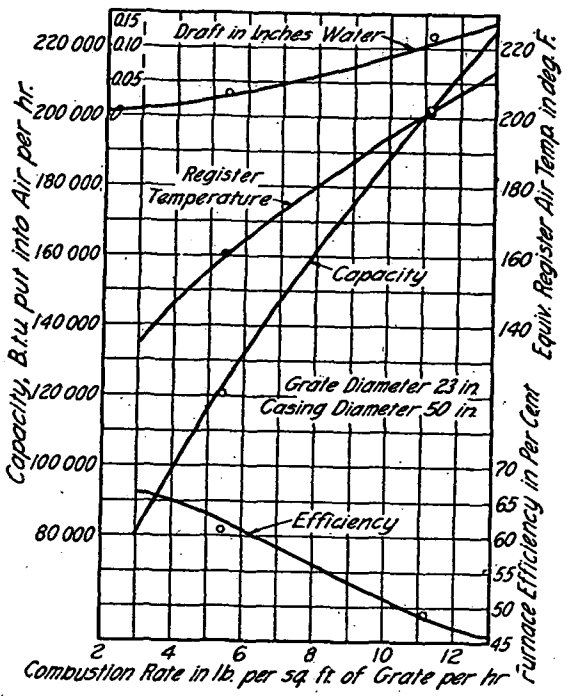


Fig. 6. Typical Performance Curves for a Warm Air Furnace and Installation in a Three-Story Ten Leader Plant, Operating on Recirculated Air

of the register. No upper floor register should be wider horizontally than the wall stack, and it should be placed either in the baseboard or side wall, if this can be done without the use of offsets. First floor registers may be of the baseboard or floor type with the former location preferred. No first floor register should require a register box more than 14 in. wide, although it may be longer than 14 in.

RECIRCULATING AIR SUPPLY DUCTS AND GRILLES

The ducts through which air is returned to the furnace should be designed to minimize friction and turbulence. They should be of ample

area, in excess of the total area of warm-air pipes, and at all points where the air stream must change direction or shape, streamline fittings should be employed. Horizontal ducts, should pitch, at least one-half inch per foot, upward from the furnace.

The recirculating grilles (or registers) should have a free area at least equal to the ducts to which they connect, and their free area should never be less than 50 per cent of their gross area.

The location and number of return grilles will depend on the size, details and exposure of the house. Small compactly built houses may frequently be adequately served by a single return effectively placed in a central hall. More often it is desirable to provide two or more returns,

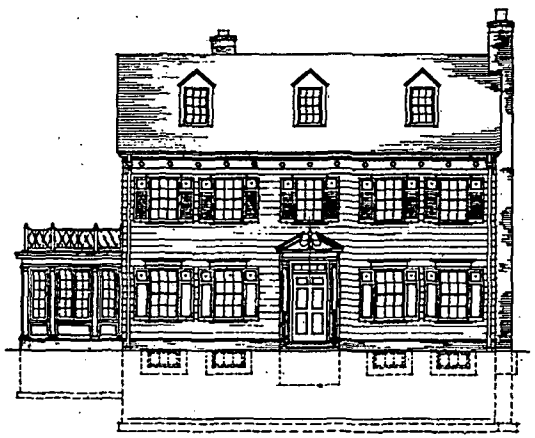


Fig 7. Elevation of the Warm Air Research Residence

provided, however, that in two-story residences one return must be placed, to effectively receive the cold air returning by way of the stairs.

Where a divided system of two or more returns is used the grilles must be placed to serve the maximum area of cold wall or windows. Thus in rooms having only small windows the grille should be brought as close to the furnace as possible, but if the room has a bay window, french doors, or other large sources of cooling and leaking of cold air, the grille should be placed close by, so as to collect the cool air and prevent drafts. When long ducts of this type are employed they must be made oversize and favored in every way. This precaution is particularly important when long ducts and short ducts are used in the same system. The long ducts must be oversize if they are to operate satisfactory, in parallel with short ducts.

Return ducts from upstairs rooms may be necessary in apartments, or other spaces closed off, or badly exposed. Metal linings are advisable in such ducts. It is important that these ducts be free from unnecessary friction and turbulence, and that they be located to prevent preheating of the air before it reaches the furnace.

Circulation is accelerated if the drop to the furnace is through a round inclined pipe with, say, two 45-deg. elbows rather than through a vertical drop and two 90 deg. elbows. The top of the shoe should never enter the casing above the level of the grate in the furnace. To accomplish this the shoe must be wide.

FURNACE

The size of furnace should, of course, be such as will provide the necessary air heating capacity, usually expressed in square inches of

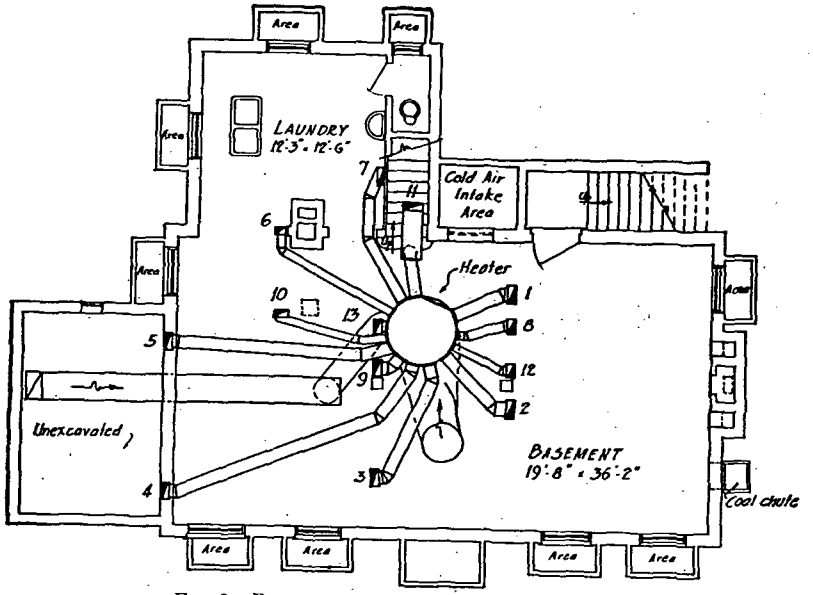


FIG. 8. BASEMENT PLAN RESEARCH RESIDENCE

leader pipe area, and at the same time provide a grate of the proper area to burn the necessary fuel at a reasonable chimney draft. The total leader pipe area required is easily obtained by finding the sum of the leader pipe areas as already designated.

The grate area will depend on several factors of which four are very important. First of all, the air temperature at the register for which the plant has been designed must be determined. Usually, this temperature is taken as 175 deg. fahr. Second in importance is the combustion rate, *which must always correspond with the register air temperature*, as is shown by reference to a set of typical furnace performance curves (Fig. 6) for a cast-iron circular radiator furnace with a 23-in. diameter grate and 50-in. diameter casing. The conditions shown on these curves which seem to approximate nearest to the 175 deg. register warm-air temperature are—combustion rate 7 lb., warm-air register temperature 173 deg., efficiency of the furnace 58.5 per cent. The third factor is efficiency, which, in turn, is a function of the combustion rate varying

with it as shown by the efficiency curve of Fig. 6. The fourth factor is the heat value per pound of fuel burned, which was 12,790 B.t.u., but is not shown on the curves since it was constant for all combustion rates.

From the relation existing between these factors it is found (Fig. 6) that the capacity of the furnace under test is 147,750 B.t.u. per hour for the total grate, which gives the capacity at the furnace bonnet per square foot of grate as 51,300 B.t.u. and per square inch of grate as 356 B.t.u. per hour.

Suppose it is desired to select a furnace to deliver air to the rooms at a register temperature approximating 160 deg. rather than 175 deg.

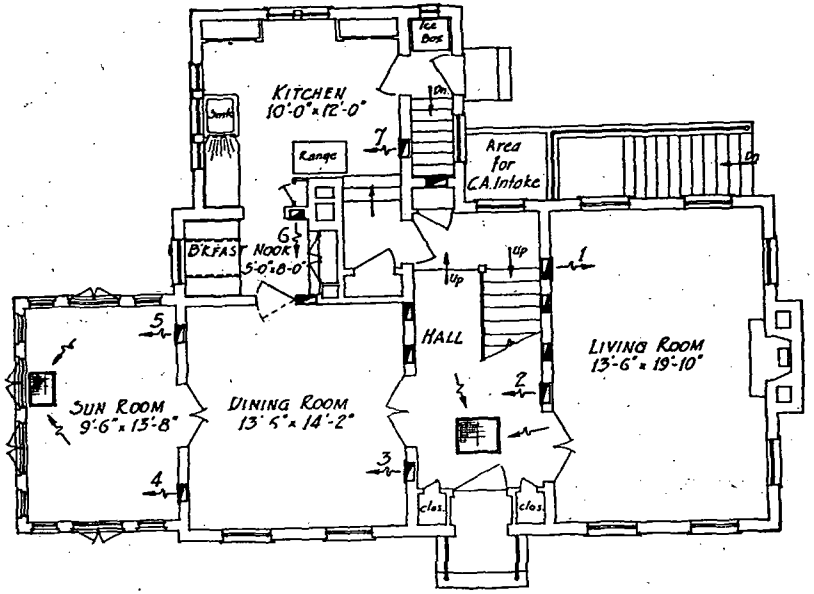


FIG. 9. FIRST FLOOR PLAN RESEARCH RESIDENCE

Referring to the curves, the relation is—combustion rate 5.5 lb., register warm-air temperature 160 deg. and efficiency of the furnace 62 per cent. Under this condition the capacity of the furnace at the furnace bonnet per square foot of grate area is 43,300 B.t.u. per hour, and per square inch of grate it is 300 B.t.u. per hour. From these performance values, the grate area for any plant requirement will be, (allowing 20 per cent heat loss between furnace and registers):

$$\text{Grate area (175 deg. register temperature), square inches } \frac{1.2\ H}{356} = 0.0034H^1 \quad (7)$$

$$\text{Grate Area (160 deg.), square inches } = \frac{1.2\ H}{300} = 0.0040H^1 \quad (8)$$

[1]Let H = B.t.u. heat loss from the entire house per hour = summation of all room losses $H_1 + H_2$ + etc. + the B.t.u. necessary to heat the fresh air if any, at intake. This fresh air loss in B.t.u. will be

approximately 1.27 times the cubic feet of air admitted through the intake per hour on a zero day. For systems which recirculate all the air this value will be zero. For systems which have a fresh air intake, controlled by damper, this value might well be approximated, since this loss will probably be reduced to a minimum on a zero day. Assume for such cases, that the building loss is increased by 25 per cent, and that there is the usual 20 per cent loss between furnace and registers.

It is not always possible to obtain performance curves, and the following method is suggested as being a close check. An addition of 2 per cent of the furnace capacity is proposed for each unit that the heating surface-grate area ratio of the furnace exceeds 20. This addition

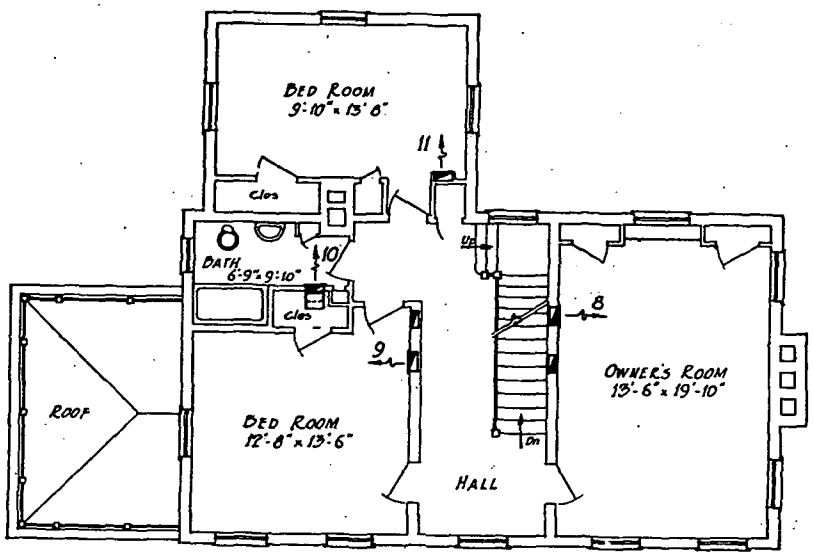


FIG. 10. SECOND FLOOR PLAN RESEARCH RESIDENCE

is based on tests of four types of furnaces having various ratios of heating surface to grate area, at the University of Illinois.

Let E = efficiency of the furnace.
f = fuel value of the coal, B.t.u. per pound.
p = pounds of coal burned per square foot grate per hour.
R = ratio of heating surface to grate area.
H = total heat requirements of the house.

$$\text{Grate area, square inches} = \frac{1.2 \times 144\ H}{Efp\ [1 + 0.02\ (R - 20)\ ]} \text{ for all inside air} \qquad (9)$$

For coal having a heat value of 12,000 B.t.u. a furnace having 60 per cent efficiency, and 6 lb. coal burned per square foot grate per hour, and 20 sq. ft. of heating surface for 1 sq. ft. of grate this becomes,

$$\text{Grate area, square inches} = \frac{1.2 \times 144\ H}{0.60 \times 12{,}000 \times 6} \text{ for all inside air} \qquad (10)$$

and for another furnace having 24 sq. ft. of heating surface for 1 sq. ft. of grate the expression is

$$\text{Grate area, square inches} = \frac{1.2 \times 144\ H}{0.60 \times 12{,}000 \times 6\ [1 + 0.02\ (24 - 20)]} \qquad (11)$$

The air temperatures at the registrars corresponding to the conditions of equation (11) would be approximately 165 deg. fahr. and for 175 deg. fahr. and 12,000 B.t.u. the combustion rate would be about 7.5 lb. with an efficiency of 57 per cent, using the curves of Fig. 6 as a guide.

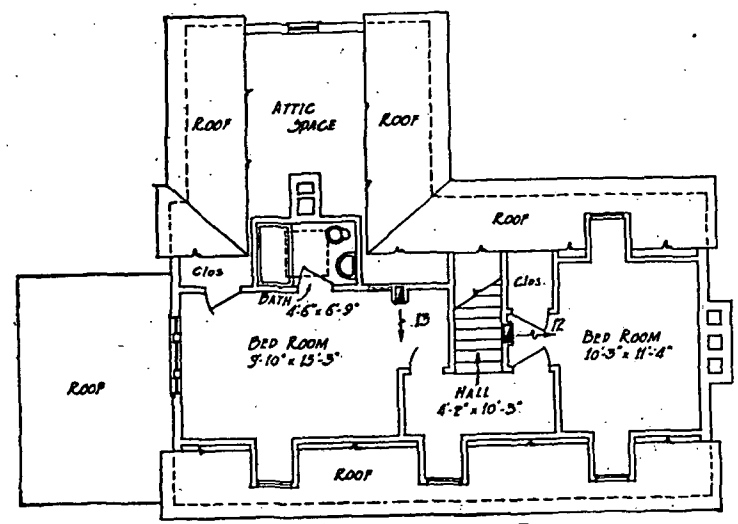


FIG. 11. THIRD FLOOR PLAN RESEARCH RESIDENCE

TYPICAL EXAMPLE

The application of the preceding data to an actual example may be of assistance to the designer. Figs. 7, 8, 9, 10 and 11,[2] represent the plans of the Warm Air Research Residence of the *National Warm Air Heating Association* erected at the University of Illinois.

Leaders, Stacks and Registers. (Direct Method)

Living Room, 1st floor:

17,250 ÷ 111 − 155 sq. in. leader area. See summary table: also Example under Standard Code, Art. 3, Basis of Working rules for pipes.

Leader diameter = 14 in.

Register size = 155 sq. in. net area. Gross area = say 1.6 × net area = 14 × 18 in.

Owner's Room, 2nd floor:

15,030 ÷ 167 = 90 sq. in. leader area. See Summary Table; also Example under Standard Code, Art. 3, Basis of working rules for pipes.

[2]Plans used with permission. Bath room on third floor not heated at present.

Leader diameter = 11.4, say 12 in.

Stack area = 0.7 × 90 = 63 sq. in. = say 5 × 12 in.

Register area = 90 sq. in. net area. Gross area = 1.6 × net area = 12 × 12 or 12 × 14 in.

In like manner the leaders, stacks and registers are calculated for each room in the house.

Leaders, Stacks and Registers. **(*Code Method. See Art. 3, Sec. 1, 2, 3.*)**

Living Room (Glass = 90, Net wall = 405, Cubic contents = 2405)

$$\text{Leader} = \left(\frac{90}{12} + \frac{405}{60} + \frac{2405}{800} \right) 9 = 155 \text{ sq. in.}$$

Register, same as Direct Method.

Owner's Room (Glass = 68, Net wall = 394, Cubic contents = 2275)

$$\text{Leader} = \left(\frac{68}{12} + \frac{394}{60} + \frac{2275}{800} \right) 6 = 90 \text{ sq. in.}$$

Stack and Register, same as Direct Method.

Assuming all air recirculated, the minimum furnace for the plant will be:

Grate Area = 0.0034 × 132,370 = 450 sq. in. = 24 in. diam. at 175 deg. register temperature. (7)

Grate Area = 0.0040 × 132,370 = 530 sq. in. = 26 in. diam. at 160 deg. register temperature. (8) (10)

If provision shall be made for certain outside air circulation, then increase the building heat loss by, say 25 per cent and obtain by equation (7) a 27-in. grate and by equations (8) and (10) a 29-in. grate.

SUMMARY OF DATA APPLIED TO WARM AIR RESEARCH RESIDENCE

Rooms	From Chapter I on Heat Losses from Buildings B.t.u. Heat Losses *H*	Leader Area Sq. In.	Stack Area Sq. In. 0.7 × *LA*	Leader Diameter Inches	Stack Size Net	Register Size Gross
First Floor		= 0.009*H*				
Living	17250	155	....	14	.....	14 × 18
Dining	6810	61	....	9	.....	8 × 12
Breakfast	2300	21	....	8	.....	8 × 10
Kitchen	9210	83	....	11 or 12	.....	12 × 14
Sun	25710	230	....	Two 12	.....	Two 12 × 14
Hall and stair	12570	113	....	12	.....	12 × 14
Second Floor		= 0.006*H*				
Owners	15030	90	63	11 or 12	5 × 12	12 × 14
S. W. Bed	9800	59	41	9	3½ × 12	8 × 12
Bath	2450	15	10	8	3 × 10	8 × 10
N. Bed	14800	89	62	11 or 12	5 × 12	12 × 14
Third Floor		= 0.005*H*				
E. Bed	8220	41	29	8	3 × 10	8 × 10
W. Bed	8220	41	29	8	3 × 10	8 × 10

STANDARD CODE REGULATING THE INSTALLATION OF GRAVITY WARM AIR FURNACES IN RESIDENCES[3]

FIFTH EDITION
March 1, 1928

ARTICLE No. 1.—Meaning of the Term "Gravity Warm Air Furnace Heating System"

Gravity Warm Air Heating Systems, to which this code refers, shall consist of one or more warm-air furnaces, enclosed within casings, together with necessary appurtenances thereto, consisting of warm-air pipes and fittings, cold air or recirculating pipes, ducts, boxes and fittings, smoke pipes and fittings, registers, borders, faces and grilles, the same being intended for heating buildings in which they may be installed.

ARTICLE No. 2.—Chimneys

a. The owner shall provide a chimney for the furnace constructed in a manner to comply with the following specifications.

b. The chimney must be absolutely smoke tight throughout its entire length, and must extend at least three feet (3′) above a flat roof or two feet (2′) above the ridges of peak roofs.

c. If built of a single thickness of brick or of cement blocks, it shall be lined throughout its entire length with fire clay flue lining, having not less than three-fourths inch (¾″) thickness. Flue lining to be laid in mortar and made air-tight.

d. The furnace flue must have no other opening for attaching any fireplace, furnace, stove, range, water heater, gas or ventilating connection.

e. If necessary to offset the flue, it must be done in such a manner as not to reduce the cross sectional area or create a ledge or obstruction, where loose material may lodge.

f. Its narrowest internal dimension shall not be less than eight inches (8″) and no flue smaller than 8″ x 8″ rectangular or eight inch (8″) diameter round will be considered suitable when hard coal is to be burned, or 8″ x 12″ rectangular or ten inch (10″) round for soft coal or wood.

g. It is strongly recommended that nothing less than 8″ x 12″ internal dimensions be used in any case.

Note 1.—It is recommended that the height above the furnace grate be not less than twenty-six feet (26′)

Note 2.—It is strongly recommended that all new chimneys be built in strict accordance with the ordinance recommended by the *National Board of Fire Underwriters.* (For further data on Chimneys, see Chapter VI).

ARTICLE No. 3.—Method for Determining Sizes of Warm Air Pipes, Wall Stacks and Furnaces for Use in Residences

Method for Determining Sizes of Basement Warm Air Pipes

Section 1. Each First Floor Room.

Divide square feet of glass by 12.
Divide square feet of net outside wall by 60. (See Table A)
Divide cubic contents by 800.
Add together the above and multiply by 9.
The result is the area of the basement pipe in sq. in.

$$\left\{ \begin{matrix} \text{The sum of:} \\ \text{Glass (sq. ft.) } (\textit{Note 3}) \div 12 \\ \text{Net Wall (sq. ft.) } (\textit{Note 4}) \div 60 \\ \text{Cubic Contents} \div 800 \end{matrix} \right\} \times 9 = \text{Area of Basement Pipe}$$

Section 2. Each Second Floor Room.

Divide square feet of glass by 12.
Divide square feet of net outside wall by 60. (See Table A)

[3]This Code is approved and issued by authority of the *National Warm Air Heating Association*, THE AMERICAN SOCIETY OF HEATING & VENTILATING ENGINEERS and the *National Association Sheet Metal Contractors*. First edition, October 1, 1922; 2nd edition, February 1, 1923; 3rd edition, June 1, 1924; 4th edition, May 1, 1927.

Divide cubic contents by 800.
Add together the above and multiply by 6.
The result is the area of the basement pipe in sq. in.
(See Section 9, *b*)

$$\left.\begin{array}{l}\text{The sum of:}\\ \text{Glass (sq. ft.) (}\textit{Note 3}\text{)} \div 12\\ \text{Net Wall (sq. ft.) (}\textit{Note 4}\text{)} \div 60\\ \text{Cubic Contents} \div 800\end{array}\right\} \times 6 = \text{Area of Basement Pipe}$$

Section 3. Each Third Floor Room.

Divide square feet of glass by 12,
Divide square feet of net outside wall by 60,
(See Table A)
Divide cubic contents by 800,
Add together the above and multiply by 5.
The result is the area of the basement pipe in sq. in.

$$\left.\begin{array}{l}\text{The sum of:}\\ \text{Glass (sq. ft.) (}\textit{Note 3}\text{)} \div 12\\ \text{Net Wall (sq. ft.) (}\textit{Note 4}\text{)} \div 60\\ \text{Cubic Contents} \div 800\end{array}\right\} \times 5 = \text{Area of Basement Pipe}$$

Basis of Working Rules for Pipes

a. These formulae are for 70 deg. temperature difference (outside temperature zero, inside temperature 70 deg. fahr.). When temperature difference is more than 70 deg., add 1½ per cent per deg. to final figures. When temperature difference is less than 70 deg., deduct 1½ per cent per deg. room final figures.

b. The values as given in Table A for use in the working rules, Article 3, Sections 1, 2 and 3 are derived as follows:

Example.—The factor 60 in Table A, Item No. 1, is based upon a coefficient of heat transmission of 0.23 B.t.u. per square foot per degree difference per hour, thus:

$W \times 0.23 \times 70 \div 111$ = sq. in. first floor leader to compensate for the heat loss through walls only. In this,

W = net area of exposed wall in sq. ft.
0.23 = coefficient of transmission in B.t.u. per sq. ft. per degree difference per hr.
70 = difference in temperature of air on inside and outside of wall.
111 = heat delivering capacity of 1 sq. in. of first floor leader pipe for a register temperature of 175 deg. fahr.

Reduced to its simplest approximate form this is

$$\frac{W \times 9}{60}$$

Likewise substitute 167 for second floor and 200 for third floor in place of 111.

The values in Table A for the different types of walls were obtained by substitution of proper coefficient of heat transmission instead of 0.23 in the above formula.

TABLE A

(The factor 60 used in Art. 3, Secs. 1, 2 and 3 is for buildings constructed as in item No. 1. When other types of walls are used substitute the appropriate factor as given below)

No. 1.—Frame wall constructed of siding, paper, sheathing, studding, lath and plaster	60
No. 2.—Frame wall constructed of siding or stucco direct to sheathing (no paper), lath and plaster	52
No. 3.—9 in. Brick Wall (no plaster)	40
No. 4.—9 in. Brick Wall, plastered one side	48
No. 5.—9 in. Brick Wall, air space, furred and plastered	65
No. 6.—13 in. Brick Wall, no plaster	53
No. 7.—13 in. Brick Wall, plastered one side	57
No. 8.—13 in. Brick Wall, air space, furred and plastered	75
No. 9.—4 in. Brick, 4 in. hollow tile, plastered	55
No. 10.—4 in. Brick, paper, sheathing, studding, lath and plaster (brick veneer)	68
No. 11.—8 in. Hollow tile stucco and plaster	67
No. 12.—8 in. Hollow tile, stucco furred and plastered	90
Roofs	
No. 13.—1 in. T & G. Sheeting, Tar and Gravel	48
No. 14.—1 in. T & G. Sheeting and Composition roof	40
No. 15.—1 in. T & G. Sheeting and Tin	24
No. 16.—Corrugated Iron on strips	9.3
Ceilings	
No. 17.—Lath and plaster without floor above	50
No. 18.—Lath and plaster with tight floor above	90
No. 19.—Metal without floor above	40
No. 20.—Metal with tight floor above	70

Method for Determining Size of Wall Stacks

Section 4. First Floor Rooms.
Same as Section 1.

Section 5. Second Floor Rooms.
Not less than 70 per cent of basement pipe area as determined in Section 2.

Section 6. Third Floor Rooms.
Not less than 70 per cent of basement pipe area as determined in Section 3.

Where two or more rooms are heated from the same basement pipe and stack, the area of such basement pipe and stack shall equal the combined areas as determined in Art. 3. Sections, 1 2 and 3.

Explanatory Notes

Note 3.—In obtaining glass surface use full casement opening. An outside door is figured as glass.

Note 4.—To obtain net outside wall multiply height by width and deduct the glass in all windows and outside doors. For all rooms with attic spaces immediately above, full ceiling areas shall be taken into account using Table A. Floors over unexcavated spaces shall be figured as 50 per cent exposed wall and fully exposed floors shall be figured as 100 per cent exposed wall.

Note 5.—For rooms having unusual exposure, ordinarily north, northeast and northwest, add 15 per cent to pipe area. For east and west exposure, add 10 per cent.

Note 6.—Use no warm-air pipe less than 8 in. in diameter. If a basement warm-air pipe figures greater area than any standard commercial size then the nearest commercial size shall be used, provided however, that the total pipe area shall in no case be less than the total requirements according to Sections 1, 2 and 3.

Note 7.—It is understood in using the above values for determining basement warm-air pipe areas, that these pipes should be run comparatively straight and that they should not be over 10 to 12 ft. in length. Sharp turns and long pipes should have extra capacity. When warm-air pipes exceed 12 ft. in length or have more than two 70 deg. turns, the next larger commercial size pipe must be used.

Note 8.—The value of 800 (used in cubic contents) is for an estimated air change of one room volume per hour. If it is desired to provide for 1½ room volume use the figure 600. If for two room volumes use the figure 400.

Transition Fittings and Stacks

Section 7. a. Transition from warm-air pipes to stacks or register heads shall be made with a well designed elbow or boot and no stack shall be less than 70 per cent of the area of the warm-air pipe leading to it.

b. All first floor fittings and connections, shall maintain a free area equal to the round basement pipes leading to them.

Method for Determining Size of Registers

Section 8. All registers shall have a free area at least equal to the area of the basement pipes leading to them.

Method for Determining Size of Furnace

Section 9. a. Add together the areas (expressed in square inches) necessary for heating the building, as determined by the foregoing calculated requirements, Art. 3, Secs. 1, 2 and 3, and install a furnace, rated by the following formula:

Furnace Rating Formula

$$L = 1.75\,G\,[\,1 + 0.02\,(R - 20)\,]$$

L = square inches of warm-air pipe connected to the furnace as calculated.
G = grate area in square inches; the area of the firepot at the grate level; its most restricted area.
R = ratio of heating surface area to grate area;
1.75 = a constant based upon the results obtained in the Association Research on a furnace having 20 sq. ft. of heating surface for each square foot of grate, and including factors for:

E = efficiency of heater;
C = combustion rate;
F = calorific value of fuel;
0.75 = percentage of heat available at registers;
136 = B.t.u. delivering value of 1 sq. in. of pipe, assuming half of the heat is sent to each floor. This value is based on an operating temperature of 175 deg. fahr. at the register.

The formula allows 1.75 sq. in. of warm-air pipe area for each square inch of grate area, for the furnace having a ratio of heating surface to grate surface of 20 to 1. For furnaces having other ratios of heating surfaces to grate surface, it adds 2 per cent or deducts 2 per cent for each unit above or below a ratio of 20.

Application:

		No. 1 Positive Correction	No. 2 No Correction	No. 3 Negative Correction
Grate area, square inch.	=	346	346	346
Heating surface area, square inch.	=	7540	6920	5665
Ratio heating surface area to grate area	=	21.8 to 1	20.0 to 1	16.4 to 1
$R - 20$	=	1.8	0.0	−3.6
Correction per cent	=	3.6	0.0	−7.2
$1.75\,G$	=	606	606	606
$L = 1.75\,G$ + correction	=	628	606	562

Certified Measurements

Certified measurements on warm-air furnaces together with the name and number of that furnace, will be issued by authority of the *National Warm Air Heating Association*, when, if and as, the grate areas and heating surfaces have been accurately measured and approved by the Research Advisory Committee.

b. In second floor duplex, flats or apartments where separate heating plants are used, add 50 per cent to the total net *calculated* areas as determined in Art. 3, Sec. 5. This represents the required warm-air pipe capacity in square inches of the furnace for the second floor.

c. Every warm-air furnace shall be equipped with a water pan or other humidifying device.

d. In the application of any gas or oil fired furnace to any warm-air heating system, any deviation from the Standard Code shall apply only to the furnace itself.

ARTICLE No. 4.—Installation—Location of Furnace

Section 1. The location of the furnace shall equalize the length of warm-air runs as far as possible, yet give necessary preference to pipes supplying living rooms, dining rooms and main halls.

Foundation

Section 2. a. Furnace foundation of brick, cement, or other incombustible material must be provided. Said foundation to extend at least fifteen inches (15″) at rear and sides of furnace casing and at least thirty-six inches (36″) in front of furnace casing. Foundation to be level.

b. Where it is necessary to place a heater on a combustible floor, not less than 4 in. (4″) of hollow tile shall be used in every instance, having joints matched in such a way that air passage will be free from side to side, so that at no time will the removal of ashes or the handling of coal close up these openings. Such foundation shall be constructed upon, and covered with continuous sheet metal plates, of not less than No. 24 gauge metal, having all joints substantially riveted or double seamed and the bottom sheet to have the edges turned up at least one inch. This floor covering shall extend under the whole of the firebox and ashpit of the furnace and outwardly not less than two feet on all sides.

Setting or Assembling of Furnace

Section 3. a. The base ring of any portable warm-air furnace shall be cemented to the foundation, and cement flushed in around the back of the base ring, making an air-tight joint. The furnace parts shall be assembled plumb and level, and in a workmanlike manner.

b. All sections and joints shall be properly fitted. Joints requiring cement shall be well filled and all bolts shall be drawn up tightly.

Casings

Section 4. a. Warm-air furnaces shall be enclosed in metal casings or walls of brick, tile or concrete.

b. Portable. Sheet metal casings including casing tops or bonnets shall be made of galvanized sheets, not lighter than 26 U. S. standard gauge. They shall fit the castings and casing rings closely, so as to be dust-tight, and shall be securely fastened to the front. The casing shall be lined from the upper casing ring down to a line on a level with the grate.

c. When side collars are used the casing top or bonnet must be of sufficient height so that the largest warm-air pipe can be taken from side without ovaling. In no case shall a distance less than eight inches (8″) be maintained between the top of any furnace and the bonnet.

d. Any furnace, the casing top of which shall come within twelve inches (12″) of a combustible floor, ceiling or joist, shall be protected by a metal shield, extending not less than eighteen inches (18″) beyond the casing of said furnace. This shield shall be suspended at least 2 in. below woodwork, allowing free air space between shield and woodwork. No furnace casing or top, coming nearer than six inches (6″) of ceiling or joists shall be allowed in any case.

e. Openings for side casing collars shall be cut into the casing top or bonnets, so that the tops of all openings are on a level. Casing collars shall be fitted into place with a proper flange, or bead on the outside and drawn up on the inside, making a dust-tight joint. All collars shall be of same size as the warm-air pipes to which they are to be connected.

f. Brick, cement or hollow tile casings shall be constructed as follows: Walls shall be not less than eight inches (8″) in thickness, and shall be constructed air-tight. The least inside dimension of rectangular casings shall be the same as that of the portable casing of a corresponding size of furnace. Walls shall be carried to the same height as the portable walls, allowing not less than eight inches (8″) between the top of the furnace and the bottom of the top cover. After placing the collars for the warm-air pipes, continue the masonry up two inches (2″) above the top of the collars, lay single or tee irons across the furnace top, spaced eight inches (8″), cover these with sheet metal not less than 26 U. S. standard gauge, cover the sheet metal with masonry or sand and run the side walls four inches (4″) above the roof of the furnace. A galvanized iron casing bonnet may be used on a brick set furnace.

Provision shall be made in the walls for a manhole to give ingress to heater.

Warm Air Pipes in Basement

Section 5. a. All warm-air pipes shall be made of bright tin not lighter than IC, or galvanized iron. Side seams shall be locked seams. All joints shall be either double seamed or lapped not less than one and one-quarter inches (1¼″) and such joints shall be match-beaded, or beaded and soldered, or riveted. All pipes and fittings shall be properly secured to ceiling or joist. No solder or riveted joint is required where round pipe slips over the casing collar or enters boot or box. Any pipe twelve inches (12″) or greater in diameter shall not be made of material lighter than IX tin or No. 26 U. S. standard gauge galvanized iron.

b. All warm-air pipes in the basement shall have an upward pitch of not less than one inch (1″) per running foot.

c. No warm-air pipe shall run within one inch (1″) of any woodwork unless such woodwork is covered with asbestos paper and the paper covered with tin or iron.

d. All warm-air pipes in the basement shall be provided with dampers supported on both sides not more than two feet (2′) from the casing.

e. Where warm-air pipes pass through a masonry wall, a metal thimble shall be provided, having a diameter at least 1 in. greater than the pipe, and pipe supported in such a manner that the air space is uniform on all sides.

Wall Stacks

Section 6. a. Single Stacks. All single wall stacks or wall pipes, heads, boots, ells, tees, angles and other connections shall be made of bright tin or galvanized iron and shall be covered with not less than one thickness of 12 lb. per one hundred (100 sq. ft.) square feet of asbestos paper. All studding and other woodwork facing said pipe shall be lined with metal and metal lath used in place of wood lath. An air space of not less than five-sixteenths (5/16″) of an inch shall be allowed on the two sides nearest the vertical studs.

All such pipes shall be braced in a proper manner so as not to obstruct the flow of air but to retain the full capacity throughout. All joints shall be locked and held in place by means of lugs, or straps. No joint shall depend wholly upon solder to make it tight.

b. Double Stacks. All double wall stacks or wall pipes, heads, boots, ells, tees, angles and other connections shall be made of bright tin, not lighter than IC or galvanized iron and shall be made double, from and including the boot or foot piece in basement to the top of each and every stack and register head on all floors. There shall be continuous uniform air space of not less than five-sixteenths ($\frac{5}{16}$″) of an inch, which must be maintained between the outer and inner walls of all such pipes and fittings of all kinds, styles and descriptions; such pipes, heads, boots and other fittings to be of the styles, or equal to those accepted by the *National Board of Fire Underwriters.*

All stacks and fittings either single or double must be secured firmly in place by lugs or straps attached to the outer walls of stacks and fittings, and no nails shall be driven through these stacks or fittings at any point. No lugs or straps shall be formed by cutting holes in outer walls of stacks or fittings. No wall pipes or fittings shall be used which depend wholly on soldered joints. The various members shall be so made that all joints are locked or soldered and the several members shall be attached to each other with slip joints, which are, for the purpose intended, air-tight.

c. Where stacks, heads, boots or other fittings, whether double or single, go through the first floor, all openings around such heads, boots, stacks or fittings must be filled with asbestos cement or other incombustible material to make the openings gas and dust-tight.

Registers

Section 7. a. When baseboard or wall registers are used, they shall be properly and permanently attached to the stack head in such a manner that will prevent any leakage of air between the head and the register.

b. Floor registers shall be provided either with register borders, or double register boxes of tin or galvanized iron with an air space of not less than five-sixteenths ($\frac{5}{16}$″) of an inch between inner and outer boxes.

c. Registers for warm air and warm-air pipes shall not be located in outside walls.

d. Any furnace system having not more than two warm-air registers, at least one of the registers shall be without valve or louvers and the pipe thereto shall be without damper.

Air Supply to Furnace

Section 8. a. The air supply to furnace for warm-air heating plants may be taken from outside or from within the building or may be taken partially from outside and partially from within. In no case, however, shall air be supplied to any furnace from any basement or furnace room not occupied as living quarters.

b. The cold air intake or return where air is taken from within the building shall have a net area throughout its entire length of not less than the combined net area of all warm-air pipes leading from the furnace. This may be maintained in one or more ducts. No reverse incline or air trap will be allowed in any section thereof.

c. When the cold air supply is taken wholly from the outside of the building the supply duct at its most contracted area must equal or exceed eighty per cent (80%) of the combined area of all warm-air pipes leading from the furnace.

d. Cold air ducts shall be constructed of metal, tile or other incombustible material having smooth inner surface and shall maintain a constant net area throughout their entire length and shall be made dust-tight. Horizontal return ducts shall have at least 10 per cent greater area than vertical connecting pipes. Where a boot or shoe is connected to the casing at the base, the opening shall not extend higher than a line on the level of the grate of the furnace. The width of the shoe shall be of proper measurement to make the area at least equal to that of the round or square pipe to which it is connected.

e. Wherever the space between joists is used to convey cold air over head, the joists and all wooden surfaces between such joists shall be lined with metal and a sheet metal pan constructed to extend not less than two inches (2″) below said joists. The connection from this pan to the boot or shoe shall be made of galvanized iron not lighter

than No. 26 U. S. standard gauge, and shall have a transition collar, the top area of which shall be at least 10 per cent greater than the area of the connecting pipe.

f. When it is necessary to set the furnace over a pit and connect up cold air under the basement floor, such pit or cold air trench shall not exceed eighteen inches (18″) in depth below the casing ring and the width of the trench or trenches shall be of proper measurement to make the area at least equal to the pipe to which it is connected. The connection between the cold air pipe or duct and the underground pit shall be made with converse transition joint as described in Article IV, Section 8 (*b*) and (*d*).

g. The cold air face or faces shall be made of wood, or metal. When set in floors the top of same shall be flush with floor. Where cold air face is placed in a seat or side wall (whether furnished by owner, general contractor or furnace contractor) the open work of face must extend to within at least one inch (1″) of the floor line.

The free area of cold air faces shall be at least equal to the free area of the duct or ducts to which they are connected.

h. The effective area of a vertical cold air face lies within fourteen inches (14″) of the floor line, hence, the capacity of any vertical cold air face shall be determined by multiplying the base line in inches by not to exceed fourteen inches (14″) in height and deducting for the grilles or cross bars.

i. When a fan is installed in the air supply duct of a gravity system the same net area of all ducts shall be maintained as calculated under Article 3, Sections 1, 2 and 3 and Article 4, Section 8–(*b*).

Smoke Pipes

Section 9. a. The smoke pipe shall be as short and direct as consistent with the location of the furnace. It shall be made of metal not lighter than No. 24 U. S. standard gauge, and not less than the full size of the collar on the furnace throughout its entire length. It must have no opening for attaching any fireplace, stove, range, water heater, gas or ventilating connection. It shall be lock seamed or riveted; all joints shall lap not less than one and one-half inches (1½″) and it shall be rigidly secured. Cast iron smoke pipe may be used.

b. All smoke pipes shall be provided with check dampers, placed on the side of the pipe or at the end of a tee; when cast iron smoke pipe dampers are used they must be placed between the check damper and the furnace and supported on both sides of the pipe.

c. Where the smoke pipe enters the flue, a thimble shall be cemented into the flue and the connections thereto made air-tight. Should any smoke pipe come within eighteen inches (18″) of any combustible material, such combustible material must be covered with asbestos paper and a metal shield so fastened that a two inch air space exists between this shield and the combustible material. This shield shall be no less in size than twice the diameter of the smoke pipe and of sufficient length to cover the combustible material at all points.

d. No smoke pipe shall project through any external wall or window. No furnace connection is to be made to a flue without a cast iron or steel cleanout having first been provided in the flue (not more than eight inches (8″) below the smoke pipe opening). The base of the flue shall be filled up to the bottom of the cleanout, all of which must be made air-tight.

Pipeless or One-Pipe Furnaces

Section 10. a. When but one duplex grating is used for both warm air and cold air in a so-called pipeless furnace, the area of the cold air intake shall be at least equal to the area of the warm-air outlet of the grating. Art. 4, Sec. 4, relative to casing shall not govern when this type of furnace is installed, but the following specification shall be followed: The inner and outer casing of this type of furnace may be made of either black or galvanized iron not lighter than No. 26 U. S. standard gauge. A uniform air space shall be maintained at all points between the inner and outer casing. In no case shall the top of the heater be allowed closer than twelve inches (12″) to any ceiling or joists above the furnace.

b. Where joists are cut to accommodate this furnace, headers shall be put in and braced.

c. Art. 3 for determining area of warm-air pipe shall not govern in figuring a pipeless furnace.

d. Where one warm-air register face is used and separate face or faces for cold air supply are used, then Art. 4, Secs. 5, 7 and 8 shall apply.

ARTICLE No. 5.—Provisions to be made in Buildings under Construction for Reception of Gravity Warm Air Heating Systems

a. The following provisions shall be made by the owner or building contractor, in any building wherein a gravity warm-air heating system is to be installed.

b. Where warm-air register boxes, heads, pipes or stacks are to be installed, joists shall be set not less than sixteen inches (16″) on centers and shall be butted and not lapped. Studding shall be set directly over and under joists, leaving a space of not less than fourteen inches (14″) between studs and joists. Wherever joists are cut, headers must be put in to support joists.

c. All first story single or sub-floors shall be continuous. In all houses having studded exterior walls, these floors shall be extended to the outside sheathing and all spaces between studding shall be closed at the attic line.

Note 9.—It is strongly recommended that the attic be tightly floored or ceilings insulated to reduce heat losses.

d. All partition walls (or sections of these walls) in which heat stacks to second or third floor rooms are to be installed, shall be of sufficient size to accommodate stacks required to heat said rooms.

FORCED OR BOOSTER CIRCULATION

Results obtained in practice, as well as in Laboratory tests, indicate that the capacity and efficiency of furnaces may be raised by the use of fans to increase the velocity of flow over the heating surfaces. The question of how much air may be forced through the furnace, without the added requirements of baffles or deflectors, before the air flows through insufficiently heated has not been determined.

Experiments at the University of Illinois[4] have shown that the capacity of a furnace may be increased nearly three times by an adequate fan, with a constant register or delivery temperature maintained, *provided that the rate of fuel consumption can be increased to provide the necessary heat.* In other words the capacity of a forced circulation system *is limited by the ability of the chimney to produce a sufficient draft.*

Several types of "booster" fan equipment, all intended to stimulate flow over the heating surfaces, are available. It is essential for obtaining increased furnace efficiency that all such devices be capable of increasing the quantity of air flowing above that flowing by gravity.

Fans of this type run at constant speeds and outputs and it is therefore inevitable that the full advantages of forced circulation with proper regulation of air delivery cannot be obtained. As a result the booster equipment is most effective in increasing efficiency at low operating temperatures. According to tests, efficiencies may be advanced from 60 per cent for gravity to 70 per cent with boosters at low operating temperatures, but at high operating temperatures gravity and booster efficiencies are almost identical.[5]

In selecting booster equipment it is important that the frictional losses and static head, against which the fan must operate, be determined and units of adequate capacity be used.

[4]See University of Ill. Eng. Exp. Sta. Bul. 120, p. 129.
[5]See Univ. of Ill. Eng. Exp. Sta. Bul. 141, p. 79.

CHAPTER IX

FAN FURNACE HEATING

Data on Furnace Performance, Temperatures and Velocity of Air, Ratings, Duct Systems.

THIS chapter covers that field of warm-air heating and ventilating in which the air is warmed by direct transmission heaters and the air circulation is maintained at all times during heating periods by means of blowers. Designated, the fan-furnace system, it is strictly mechanical and is comparable to the common steam blast system. For data on booster fans in conjunction with gravity warm-air furnaces (See Chapter VIII) and for direct-fired unit heaters (See Chapter X).

The fan-furnace system of heating provides a positive circulation of either outside air or return air over direct transmission heaters, through ducts to various rooms in the building and thence to the atmosphere by exhaust or back to the fan for recirculation. The use of fans permits warm-air heating and ventilation to be easily provided in larger buildings than could be properly handled by gravity means.

When first introduced, fans were used with the existing gravity furnaces, but gradually the practice developed of building heaters particularly designed for fan service. Due to the fact that the fan could be made to deliver any given volume of air against higher resistances, the free area through the fan duty heaters was reduced by interposing more heating surface in the path of the air and creating a more intimate contact between the air and the heating surface.

Fan furnaces must be designed to secure this increased heating surface, fire travel and grate area within economical space limits. Many of the heaters of larger capacity are designed horizontally to secure these features and to properly care for expansion and contraction.

A furnace system affords a direct transfer of heat from fuel to air, has few parts, gives quick response with high temperatures and contains no water to scale, corrode or freeze.

HEATER ARRANGEMENT

Any number of furnaces can be set in battery; all to be enclosed by an outer casing consisting of either brick or insulated metal. This casing provides space under the heaters for air supply and forms a plenum space above furnaces from which ducts lead to space requiring heat.

The fan is preferably placed at the rear of the heaters to secure equal air distribution over heating surfaces. It is considered best practice to

Material for this Chapter prepared especially for THE GUIDE by the following committee: J. H. Kitchen, *chairman;* Bert C. Davis, Lloyd Howell, E. B. Langenberg and J. C. Miles.

blow air through heaters rather than to draw through by suction and most fan furnaces are designed for this arrangement.

The fan-furnace system can be readily applied to each of the following standard duct systems or any combination thereof:

1. The straight fan blast trunk line system carrying heated air only for a series of rooms on any one run.

2. The double duct system furnishing warm air in one and tempered air in the other, the mixture to be secured near the room heated and ventilated.

3. The individual duct system with separate ducts to each room, providing mixture of warm and tempered air at the furnace casing.

In general the fan blast duct design follows standards set forth in Chapter XXVIII (Air Duct Design and Construction). The use of fan-furnace system enables the same freedom of design in ducts as does any other blast method of heating.

The fan-furnace system can also utilize many of the well known devices which will greatly improve its operation. Several of these additions are as follows:

First.—Automatic temperature control.
Second.—Humidifying apparatus.
Third.—Use of air washer.
Fourth.—Humidity control.
Fifth.—Use of air filters.
Sixth.—Use of ozone.

Automatic temperature control can readily be used on the trunk line system of ducts, the double duct or the individual duct. See Chapter XVI for control of tempered air.

For all plants a warm-air plenum thermometer, indicating the temperature leaving the heater, is of great assistance for proper operation.

Humidifying pans connected to outside water supply and regulated by a float valve mechanism are frequently used for humidification. To accelerate vaporization, water coils, connected to humidifying pans, extend inside the combustion chamber, but must be carefully sized to prevent excessive steaming.

Automatic control of humidity can be secured by means of sprays or air washers controlled through humidistats. It is necessary to introduce a warm-air supply in front of the air washer or to use heated water to prevent freezing.

The further use of air washers in conjunction with refrigeration installations is practical with this system as in other blast plants. This is also true with all styles of air filters. See Chapter XXV (Air Conditioning and Cooling) and XXIX (Air Cleaners).

Wherever recirculation is used extensively, ozone may be applied. See Chapter XXX (Ozone in Ventilation).

FUEL

Coal, oil and gas fuels are commonly used with fan furnaces and there are many heaters particularly designed for the use of a particular fuel. Anthracite, semi-anthracite, semi-bituminous and bituminous coals are suitable when selected in the proper sizes. The fan-furnace system lends itself to the burning of buckwheat coal by using forced draft from fan

and grates with small air spaces. For burning small sized bituminous coal, a stoker or Dutch oven can easily be added. See Chapter VII (Mechanical Draft).

Where oil fuel is used in larger buildings using batteries of heaters, manually controlled mechanical atomizing oil burners are generally used. Care must be exercised in selecting the proper size oil burner and baffling arrangement to produce a clean fire. Burners are generally inserted in the ashpit door to secure greater combustion space. For smaller installations the automatic type of burner may be applied. With either type of burner it is desirable to supply fan motor with automatic starter governed by plenum room temperature and a time limit control for burner cut off in case of fan failure.

It is also advisable to install an electric oil preheater in connection with fan-furnace systems unless steam is available for warming the oil. This applies more particularly to those installations using heavier grades of fuel oil.

In connection with the burning of gas, good results have been obtained with a burner having a number of jets, or burning points, spread out in horizontal plane and approximating a coal fire on grates. Nozzle type burners inserted through the ashpit door with grates removed work satisfactorily if proper baffling is employed to secure a maximum impingement of the hot gases on the heating surface.

In any case it is important to have a damper in the smoke connection from each heater to the breeching for the purpose of adjusting the draft conditions to suit whatever gas burner is selected but in no case should such damper restrict the entire area of the smoke connection.

Another wise precaution is to provide ample air supply for combustion from outside the building to the firing space in front of the heaters, this would also dilute any accumulation of gas which might originate from leaks in pipe or valves.

As safety features, each installation of gas burners should be fitted with safety pilot lights and a temperature limit control in the warm-air plenum space in conjunction with an automatic snap valve. These last will function to shut off all gas to the burners in the event the pilot lights go out or in the event the temperature in the warm-air plenum exceeds any set point.

See Chapter XIV for further information on gas burning.

APPLICATIONS OF FAN FURNACE HEATING

The fan-furnace system is adapted to public and industrial buildings including schools, churches, theatres, auditoriums, convention halls, factories and garages. In each case the building plans largely determine which type of duct system can be most advantageously used. State laws, city ordinances, or the wishes of the owner dictate the percentage of outside air to be figured. Insofar as the design of the ducts is concerned, the engineer has only to follow his customary practice in ventilating work. That is to say, he can calculate the ducts either on the velocity basis or the pressure loss basis, using the same velocities, data, temperature ranges and methods he would in planning any other system of forced air circulation for heating and ventilation. (See Chapter XXVIII.)

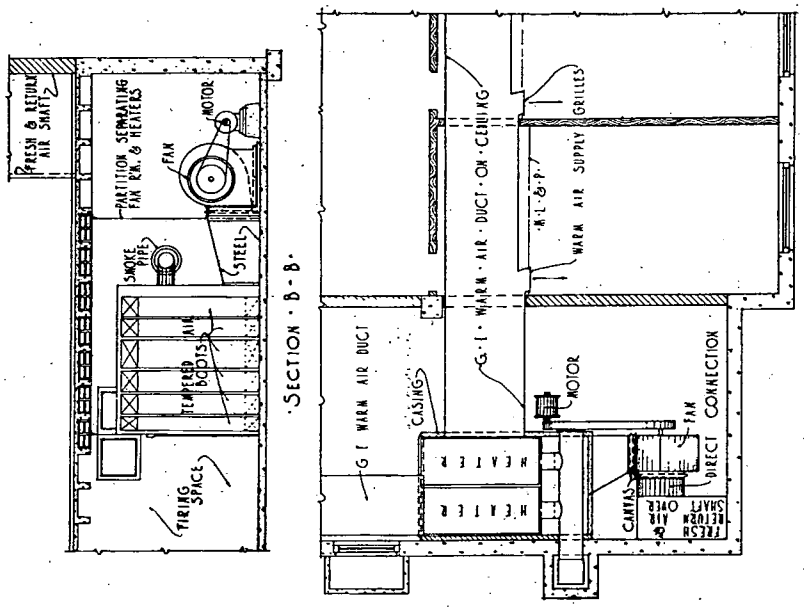


FIG. 3. FAN FURNACE WITH SINGLE DUCT

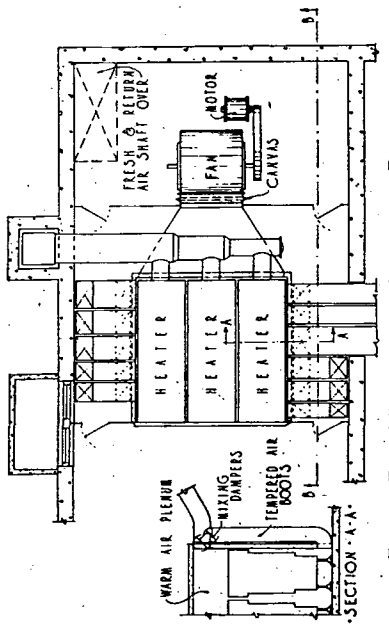


FIG. 1. FAN FURNACE WITH INDIVIDUAL DUCTS

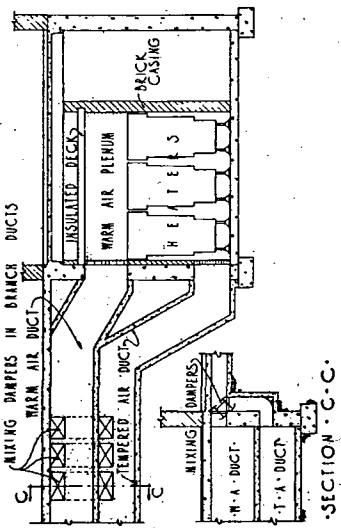


FIG. 2. FAN FURNACE WITH DOUBLE DUCTS

Direct transmission heaters for fan-furnace systems are to be had made of cast-iron or steel. The former are made in sections which are cemented and then bolted together on the job; steel heaters are assembled with welded or riveted joints.

Efficiency of Heating Surface

The emission of heat from the heating surface of these furnaces will vary from 2000 to 3000 B.t.u. per square foot per hour; 2500 is a good average value.

Ratio of Heating Surface to Grate

In commercial sizes the ratio of the heating surface to the grate surface will vary from 30 to 1 to 50 to 1.

Free Area and Resistance

The free area through the heaters and resistance to the flow of air at varying velocities are characteristics depending upon the heater in question.

RATINGS

This class of equipment is usually rated in one of three ways, as follows:

1. The temperature rise of the air is listed over a certain range of velocities through the free area of the heater for varying combustion rates, for a certain heating value of the fuel.

2. The volume of air in cubic feet per minute is listed over several temperature rises with the necessary fuel consumption, taking coal of some known heating value as a standard.

3. The B.t.u. imparted to the air is listed for varying combustion rates.

Either of the first two methods is preferable to the third because of the inaccuracies that are apt to creep into the latter, due to the fact that for the same combustion rate on any given heater, the B.t.u. imparted to the air will not remain constant, but will vary with the volume of air passed over the heater.

SELECTING THE HEATER

In selecting heaters for any particular work, the engineer should be governed by certain considerations that arise through the nature of the service for which the plant is intended. The volume of air to be passed over and through the heaters limits the free area required in the latter, once the velocity at this point is agreed on. It will be evident that more heater capacity is required to offset the heat losses of a building with outside air than with recirculated air. Consequently when designing a plant for operation on recirculated air, the volume of air per heater will be considerably larger than would be the case for outside air. If the velocity through the heater in this case is not investigated, it may become excessive thus increasing the static resistance of the system unduly, spelling larger power bills for the owner. The free area may easily be increased by using wider casings, thus reducing the resistance and power

TABLE 1. AIR VELOCITIES AND REGISTER TEMPERATURES FOR FAN FURNACE SYSTEMS

TYPE OF BUILDING	VELOCITIES IN FEET PER MINUTE							REGISTER TEMPERATURE
	Thru Free Area of Heaters	In Horizontal Heat Ducts	In Heat Risers	Into Room	In Vent Outlets	In Vent Risers	In Horizontal Vent Ducts and Recirculating Ducts	
Schools	800 to 1000	800 to 1000	500 to 600	300 to 400	300 to 400	500 to 600	600 to 800	90° to 120°
Churches	800 to 1000	700 to 900	400 to 600	300 to 500	300 to 500	400 to 600	500 to 700	80° to 120°
Auditoriums and Convention Halls	800 to 1000	800 to 1000	500 to 600	300 to 500	300 to 500	500 to 600	600 to 800	80° to 120°
Garages and Industrial Buildings	1000 to 1400	1000 to 1400	600 to 1000	400 to 1000	400 to 600	600 to 1000	800 to 1200	80° to 140°

consumption. In practice, velocities through the free area of the heaters are used as follows:

1. Schools, Churches, Auditoriums, Theatres, etc., from 800 to 1000 ft. per minute.
2. Industrial Buildings, Factories and Garages, from 1000 to 1400 ft. per minute.

The importance of power costs effects the decision as to what free area and static resistance are allowable.

The thermal efficiency of the various makes of heaters is a consideration deserving some thought in case the fuel to be burned is relatively high in cost.

First cost and fuel economy are items that also bear on the type of casing to be employed.

One of the most important considerations is the durability or life of the apparatus. Investigation of the several makes of heaters contemplated submitted to him should include such data as the thickness of the metal in each heater, the provisions made for expansion and contractions, and the protection afforded the firebox at the point of most intense heat.

A heater made of thicker metal than others will naturally give greater length of service, all other things being equal.

Proper provisions for expansion and contraction are imperative. Without such provisions a cast-iron heater is likely to crack and a steel heater is likely to warp and buckle.

Most furnaces have linings around the periphery of the fuel bed to protect the firebox from the action of the hottest part of the fire. The linings are removable and are as easily installed as new grates.

SUGGESTED METHODS OF PROCEDURE IN DESIGN OF FAN FURNACE SYSTEMS

1. Calculate Heat Loss of each room in building.

   See Chapter I.

   Example.—Assume school room with cubic content 6550.
   Heat loss = 45,269 B.t.u.

2. Determine volume of air per minute.

   Based on number of occupants.

   Based on number of air changes.

   Example.—Assuming 33 occupants; 30 C.F.M. per occupant.
   33 × 30 = 990 C.F.M.
   6550 content = 6½ minutes air change or approximately 9 changes per hour.

3. Figure diffusion temperature of air for each room.[1]

   Example.—Diffusion Temperature = $\frac{56 \times h}{60 \times v} = \frac{56 \times 45.269}{60 \times 990} = 42.3$ deg.

4. Determine required register temperature.

   Register temperature equals room temperature plus diffusion temperature.

   Example.—Assume 70 deg. room temp.
   42.3 deg. plus 70 deg. = 112.3 deg.

5. Set final temperature of air leaving heater.

   Final temperature equals register temperature plus allowance for loss in ducts.

   Example.—
   112.3 deg. register + 10 deg.
   Loss in ducts = 122.3 deg.

6. Determine temperature rise through heater.

   Temperature rise equals final temperature minus initial temperature.

   Where part outside and part recirculation is used.

   Initial temperature approximately equals $P_o T_o + P_r T_r$.

   P_o = percentage outside air.
   T_o = temperature.
   P_r = percentage recirculated air.
   T_r = temperature recirculated air.

[1]The diffusion temperature may be defined as the number of degrees the volume of air as determined under Item 2 must be *in excess* of the room temperature, in order to offset the heat loss by cooling over that range. In other words it is the number of degrees representing the difference between the necessary supply register temperature and the room temperature for the conditions under which the heat losses are calculated in Item 1. It is readily calculated by using the following formula:

Diffusion temperature = $\frac{56\,h}{60\,v}$ where h is the heat loss in B.t.u. per hour, v is the volume of air in cubic feet per minute measured at 70 deg. fahr. for the room in question.

Example.—
Temperature rise 122.3 deg. − 0 deg. = 122.3 deg. with all outside air.
or
Assume 50 per cent outside air 0 deg.
50 per cent recirculation 60 deg.
$P_oT_o + P_rT_r = (0.50 \times 0)$
$(0.50 \times 60) = 30$ deg. initial temperature.
Temperature rise through heater = 122.3 deg. − 30 deg. = 92.3 deg.

7. Calculate required free area through heaters.[2]

Select velocity through heaters suitable to problem.

$$\text{Free area} = \frac{\text{Total C.F.M.}}{\text{Vel. in F.P.M.}}$$

Example.—Assume total C.F.M. of all rooms = 21,000.
Assume 900 F.P.M. through heater. (See table.)
$\frac{21{,}000}{900} = 23.3$ sq. ft. free area.

8. Select size and number of heaters.

Take temperature rise from 6.
Take free area from 7.
Assume maximum allowable combustion rate for fuel to be burned and stack available.
Note resistance of heaters for air volume.
Select suitable heaters from ratings.

9. Design duct system.

Ducts may be designed according to standard practice.
See Chapters VIII and X.

10. Calculate total static pressure for entire system.

11. Select blower.

See Chapter XXVI and Fan Manufacturers tables.

12. Select motor (See Chapter XXVII).

13. Select drive.

[2]Some heaters are rated on the basis of the volume of air that may be warmed over any given temperature range for all heater sizes and list the static resistance in each instance. In this case the free area need not be calculated, but the combustion rate should be investigated.

CHAPTER X

UNIT SYSTEMS FOR HEATING AND AIR CONDITIONING

Industrial Types, Direct Fired Units, Air Conditioning Units, Piping Connections.

INDUSTRIAL UNIT HEATERS

THE unit heater for industrial plant application is composed of a radiator or heating element enclosed by a casing in which a power driven fan or fans are mounted. The fans draw or force air over the heating surface where it is heated and discharged in selected directions. Unit heaters are placed directly within the room to be heated and discharge the heated air into the enclosure, where it is distributed uniformly over wide areas under the direct impulse of the fans and by the currents of circulation set up.

The function for which unit heaters are designed are: To circulate the air in the building at a rapid rate; to promote uniformity of temperatures and quick heating-up; to control and direct the heated air for the positive and rapid placing of the heat where it is effective; to distribute heat over wide areas, to reduce the number of units and simplify piping and installation; to increase the capacity of the heating surface by passing the air over it at high velocity; to provide a system by which room temperatures are readily controlled manually or by thermostats.

Different types of unit heaters are built to suit various purposes. Most employ a heating coil to be supplied with steam or hot water. Some are designed primarily for mounting on the floor, others for suspension overhead. Heating surfaces in the form of pipe coils, non-ferrous tubes or shapes with extended surfaces, cast-iron, pressed and built-up sections of the cartridge or automotive type are all used in one or more of makes available. Fans employed are the disc or propeller, housed centrifugal and cone types.

Unit heaters may be arranged to recirculate the air or to supply warmed air from the outside for ventilation or to make up air exhausted. One type combines a means for exhausting air with the above functions. In addition to their prime function of plant heating, they may be adapted to a number of industrial processes, such as drying, curing, etc. Here the use of heated air in more rapid circulation with uniform distribution is of particular advantage. They may be used for moisture absorption, such as fog removal in dye-houses or the prevention of condensation on

Material for this Chapter especially prepared for THE GUIDE by the following committee: Thomas Chester, *chairman;* D. E. French, E. P. Heckel and W. A. Rowe.

roofs or cold surfaces of buildings where process moisture is given off. When such conditions are bad, it is necessary that the heaters draw air from outside in enough volume to provide a rapid air change and that they operate in conjunction with ventilators or fans for exhausting the moisture laden air.

Unit heaters are made to operate on hot water, vacuum or vapor steam systems or steam at any pressure up to 200 lb. or more. When high pressure steam is used, a heater must be selected with the coil especially designed to withstand the maximum pressure that will exist.

It is usual to rate unit heaters in B.t.u. per hour at a given temperature of air entering the heater and a given steam pressure maintained on the coil. Steam at 2 lb. pressure and air entering at 60 deg. fahr. are usually taken as standard. The B.t.u. capacity of a heater increases as the steam pressure increases, and decreases as the entering air temperature increases. The B.t.u. capacity for any condition of steam pressure and entering air temperature may be calculated from any given rating by the use of factors in Table 1.

TABLE 1. B.T.U. CONSTANTS FOR VARIOUS STEAM PRESSURES AND TEMPERATURES OF ENTERING AIR

Steam Pressure Lb.	Temperature of Air Entering Heater												
	−10°	0°	10°	20°	30°	40°	45°	50°	55°	60°	65°	70°	75°
0	0.975	0.93	0.89	0.84	0.80	0.76	0.73	0.71	0.69	0.67	0.64	0.62	0.60
2	1.01	0.96	0.92	0.87	0.83	0.79	0.76	0.74	0.72	0.70	0.68	0.65	0.63
5	1.04	1.00	0.96	0.91	0.87	0.82	0.80	0.78	0.76	0.74	0.71	0.69	0.67
10	1.06	1.05	1.01	0.97	0.92	0.88	0.85	0.83	0.81	0.79	0.76	0.74	0.72
15	1.15	1.10	1.05	1.01	0.97	0.92	0.90	0.88	0.86	0.83	0.81	0.79	0.76
20	1.18	1.14	1.09	1.05	1.00	0.96	0.94	0.92	0.89	0.87	0.85	0.83	0.81
30	1.25	1.21	1.16	1.12	1.08	1.03	1.01	0.98	0.96	0.94	0.92	0.90	0.88
40	1.30	1.26	1.22	1.17	1.12	1.08	1.06	1.04	1.02	1.00	0.97	0.95	0.93
50	1.35	1.31	1.27	1.22	1.18	1.13	1.11	1.09	1.07	1.04	1.02	1.00	0.98
60	1.39	1.35	1.31	1.26	1.22	1.18	1.16	1.13	1.11	1.09	1.07	1.05	1.03
80	1.49	1.43	1.38	1.34	1.29	1.25	1.23	1.20	1.18	1.16	1.14	1.12	1.10
100	1.53	1.49	1.44	1.40	1.35	1.31	1.29	1.26	1.24	1.22	1.20	1.18	1.16
125	1.59	1.56	1.51	1.46	1.42	1.37	1.36	1.33	1.31	1.29	1.27	1.24	1.22
135	1.61	1.57	1.53	1.48	1.44	1.39	1.37	1.35	1.33	1.30	1.28	1.26	1.24
140	1.62	1.58	1.54	1.49	1.45	1.41	1.38	1.36	1.34	1.32	1.29	1.27	1.25
150	1.64	1.60	1.55	1.51	1.46	1.42	1.40	1.38	1.35	1.33	1.31	1.28	1.26

Note.—To get B.t.u's at any steam pressure and entering temperature, multiply constant from table by rated B.t.u's at 0 deg. entering and 5 lb. pressure.

The B.t.u. required to heat a building with unit heaters is determined in the same way as for any other heating equipment. (Use data in Chapter I).

If all or a part of the air is to be taken in from out-of-doors the B.t.u. necessary to heat this air from the outside temperature to the inside temperature must be added. Unit heaters of the number and size needed to furnish this quantity of B.t.u. are then selected from the manufacturers rating tables, using their ratings at the steam pressure to be used and at the temperature at which the air will enter the heater.

For recirculating heaters with intakes at the floor level, use the tem-

perature to be maintained in the room as the temperature of the air entering the heater and where suspended heaters are used without any intake boxes extending down to the floor level, a higher entering air temperature should be used than that at which the room is to be maintained. With suspended heaters taking in air at some distance above the floor, the temperature variation from floor to ceiling has been found to be approximately 1 deg. fahr. for each foot of elevation. Unit heaters taking in recirculated air at the floor level will maintain temperature differentials of less than 1 deg. per foot of elevation. These temperature differences per foot of height are less than the corresponding variations for spaces heated by direct radiation.

Heaters supplied with superheated steam will have less B.t.u. capacity than with saturated steam at the same pressure. When superheated steam is supplied or when the steam in the heater coils is superheated by throttling from a higher line pressure, the heater manufacturer should be asked for a special rating for the conditions of the case.

The present day tendency for straight heating is to use steam at low-pressure when the boiler supplies steam for heating purposes only and when the transmission lines are short. Many industrial plants, however, generate steam at high pressure either for long distance transmission or process uses. When such high pressure steam is available in sufficient quantity for the heating load, it is most often more economical to select heaters with coils good for high pressure. Thus the line pressure may be turned into the coils directly without reducing valves, fewer or smaller heaters can be used and the condensation can be boosted to overhead returns whenever desirable to do so.

Among the unit heaters available are types having from one to four outlets that can be arranged to discharge in selected directions and that will project their heating effect over distances of from 30 to 200 ft. from the heater, depending upon the capacity of the heater and the design of the fans and outlets. This leaves the engineer comparatively free to select the heater location best suited to the production layout.

The smaller capacity propeller fan type heaters with outlet velocities from 300 to 600 ft. per minute may be placed from 60 to 100 ft. apart. The larger capacity housed fan high outlet velocity heaters may be placed up to 400 ft. apart, depending upon their design. Heaters may be distributed through the central portions of a room discharging toward exposed surfaces, or spaced around the walls, discharging along the walls and inward as well, when there are considerable roof losses. In general, it is better to direct the discharge from the unit heater in such fashion that rotational circulation is set up by the system rather than having the heaters discharge in random and counter directions.

Usually hot blasts in the working zone are objectionable, so heaters mounted on the floor should have their discharge outlets above the head line and suspended heaters should not be placed so low or turned in such direction that the heated air stream will not be objectionable in the working zone. In the interest of economy, however, the elevation of the heater outlet and the direction of discharge should be so selected that the heated air is brought as close to the head line as possible, but not into the working zone.

Unit heaters should be carefully air vented and usually a blast type trap of at least 50 per cent excess capacity should be used to take care of the load during the heating-up period. During that period the temperature of the air entering the heaters is low and the heaters therefore condense more steam than they do when the building is up to temperature. Steam pressures below 5 lb. can be used with safety for recirculating heaters when proper provision is made for returning the condensation. If heaters are to take in air that might be at a temperature below freezing, a steam pressure of at least 5 lb. should be maintained on the heater coils.

Stopping the fan motor but with steam on the coils reduces the heat output 70 to 95 per cent, depending upon the design of the heater. Thus room temperatures can be controlled by starting or stopping the fan motor on one or more of a group of units. This can be done manually or by means of a simple thermostat which makes and breaks the circuit either direct to the motor for fractional horsepowers or through an automatic starting switch. Of course the heat output of the heater may also be controlled by the throttle valve to the heater coil. This can be done thermostatically either with a graduated or with an on and off action. In some applications thermostatic controls to both the motor and the steam valve are used in conjunction.

What has been said relates generally to units in which steam or hot water is used as the heating medium. On rare occasions electrical resistances are used as the heating element but are applied only where electric power is abundant and cheap and other forms of fuel scarce and expensive.

DIRECT FIRED UNITS

In places where these heating mediums are not available the direct-fired type of heater is used. Here the heating element is a firebox in which coal, coke, oil or gas is burned directly. This firebox is enclosed in a casing in which fans are mounted so as to draw air over the firebox, and combustion chamber and discharge it directly into the room. This type of heater is also used for temporary heat or where the installation of a steam or hot water plant is for some reason not justified.

AIR CONDITIONING UNITS

A recent development has been the introduction of self-contained unit air conditioning devices. Essentially an outfit of this kind consists of a unit heater with the addition of an air-washer, humidifier or dehumidifier. Several types are on the market and are being used, in certain cases, to render a service similar to that produced by the well known types of central air conditioning systems, which central systems are equipped with supply air ducts for uniform distribution of conditioned air and recirculating ducts for returning the air to the apparatus.

In most lines of manufacture where the product is of such value as to necessitate the use of air conditioning equipment, it may be considered imperative to provide a highly uniform delivery of conditioned air. A few years ago it was considered necessary to install a return duct system similar to the supply ducts, but recent practice has been to eliminate

many of the smaller branch return ducts and pick up the return air in comparatively large volumes at suitably spaced return intakes. A logical development of this trend is to eliminate the delivery ducts, also, by the use of individual air conditioning units.

Good judgment and thorough knowledge of the art are prerequisites for the design of both unit and central types of air conditioning apparatus. For some purposes it will probably be satisfactory to deliver conditioned air from one or more units suitably located within an enclosure.

An air conditioning unit is so designed that it will draw in air from the room or enclosure in which it is placed or it will draw air from the outside, or through a medium of mixing dampers; it will also draw any predetermined mixture of the two. This entering air passes through one or more spray or mist chambers, in which space, moisture is either added to or removed from the air in accordance with the temperature of the air and of the spray water and at the same time the air is washed substantially free of dust and solid matter. The air next travels between the customary labyrinth eliminator plates to lose its entrained water.

A suitably located fan assembly causes the air to flow over a heating element and the conditioned air is delivered to the room. A motor-driven centrifugal pump or other means is used to take water from the tank built into the base of the unit and deliver this water under a suitable pressure to the spray heads, mist nozzles or other atomizing apparatus. In some makes of unit conditioners spray nozzles have been discarded in favor of other means of producing the required water spray or mist for the transfer of heat from air to water or vice versa. Automatic instruments control the condition of the leaving air by regulating the temperature of the spray water and also the amount of steam supplied to the air heater. Such instruments are usually placed in the path of the return air as it enters the unit to be conditioned, as the entering air is a sample of room air. The spray water can be heated by either an ejector or closed type heater, in the usual manner for humidifying purposes.

For dehumidifying work cold water can be supplied under automatic control as needed. It will be found best to employ a separate water cooler located in close proximity to the compressors and condensers, where artificial refrigeration is used, instead of making use of direct expansion coils or brine coils within the air conditioning units.

Unit air conditioning equipment may be of the following types: (1) the air washer type which does not control the moisture content or temperature of, but simply cleans the leaving air, (2) the humidifying type which controls the relative humidity without washing the air or controlling its temperature, (3) the complete air conditioning unit, which washes the air, controls its moisture content and heats or cools the room within which the unit is located.

In addition to the use of air conditioning purely for human comfort, there are many industries where the materials handled are hygroscopic in nature, and where the processes are greatly facilitated by the use of conditioned air. An example is a printing plant where many difficulties such as those from static electricity or from improper register are encountered with the paper as it passes through the presses.

There are certain other industries whose higher existence depend upon

the reproduction day after day of the same air conditions. An example is, a bakery where the quality of the bread is almost entirely dependent upon the condition of the air in the fermentation room and the proof box.

Tobacco, textiles, paper, rubber, candy and celluloid are a few of the products with which conditioned air may be used to advantage during the manufacturing process.

Conditioning units lend themselves very well to the production of different air temperatures and humidities in the different rooms or departments of a manufacturing plant. When equipped with automatic control they very effectively reproduce the same conditions day after day. Additional units can be added to keep pace with the growth of a department and they can also be moved from one room to another to suit plant alterations or changes in production routine.

In a plant where several units are being used, the breakdown of one unit does not seriously impair the production, inasmuch as the remaining units will furnish a considerable quantity of conditioned air until the disabled unit is repaired.

Other possible advantages are small first cost due to elimination of supply and return ducts, small operating expense due to low air pressure required with the absence of ducts and high salvage value. Possible disadvantages are maintenance costs, cost of supply and return lines for water and steam, cost of electric wiring and possible difficulties met with in keeping a number of sets of regulating and controlling devices in good operating condition.

PIPING CONNECTIONS FOR UNIT HEATERS

Piping connections for unit heaters are similar to those for other types of fan blast heaters.

One-pipe gravity and vapor systems are not recommended for unit heater work. On two-pipe gravity or pump and receiver systems the return from each unit should be fitted with a blast trap or a heavy duty thermostatic trap and an air valve should be connected into the return header of each unit.

On vacuum systems the return from each unit should be fitted with a blast trap to discharge the water of condensation and with a thermostatic air trap for eliminating the air, or with a heavy duty thermostatic trap for handling both the condensation and the air, provided the air can be finally eliminated at some other point in the return system.

On high-pressure systems the same kind of traps may be used as with vacuum systems, except that they must be properly constructed for the pressure used. If the air is to be eliminated at the return header of the unit, it is customary to use pet cocks, otherwise the air is passed with the condensate through the high-pressure return trap.

CHAPTER XI

CENTRAL HEATING SYSTEMS

Typical Service Connections, Control Devices, Underground Distribution Systems, Expansion and Contraction, Conduits and Tunnels, Insulation, Steam Requirements for Different Types of Buildings.

THE object of this section is to present the outstanding engineering features of central station heating, omitting any discussion of contracts, rates and other commercial features. A great deal of the information given will apply not only to the public utilities generally classed as district heating systems, but also to those institutional groups supplied from a central source, and perhaps better classified as central heating systems.

SERVICE CONNECTIONS FROM HIGH PRESSURE AND LOW PRESSURE SYSTEM

The practice of two companies in connecting the customer's premises with the street system are shown in accompanying sketches. Figs. 1 and 2 show the methods employed by a Boston utility for cooling condensate of customer's steam systems before discharging the condensate to the meter. Similar requirements pertain where customers purchase steam by flow meter. In the latter case, however, the company does not insist that the customer meet the requirements completely as any loss in metering is borne by the customer. A vacuum or condensation return pump may be attached to these systems.

Fig. 3 shows a typical installation for service from the system of a New York utility. The practice followed by utilities in other localities may be found in the Handbook or the Proceedings of the *National District Heating Association.*

CONTROL OF STEAM SUPPLY

Because radiation for a building must provide for maximum load conditions, variable weather in many localities brings the problem of variable steam demand from the various heating elements in the building. This condition may be controlled by hand method or by any one of the systems of automatic heat control described in Chapter XVI. Another form of regulation, known as the time limit control, is sometimes employed for regulating the steam supply from the central station main to the building.

Such a control provides an intermittent supply of steam to the radiation either throughout the 24 hours of the day or during the daytime hours only. The setting of a switch may provide no service, continuous service,

---

• The material for this chapter was especially prepared for THE GUIDE by the following committee: George W. Martin, *chairman;* A. S. Armagnac, D. S. Boyden, Walter J. Kline, Edward Lenz, L. B. McMillan, A. W. Moulder, George B. Nichols, and Ralph C. Taggart.

or periodic service. For the latter, by means of several intermittent settings, steam will be supplied, during each period, in increments of a certain number of minutes for each successive setting of the switch, steam being shut off during the balance of the period. These settings afford from 15 to 80 per cent of that maximum heating effect, required on days of zero temperature.

A night switch with a variety of settings, may be adjusted so as to maintain throughout the night the intermittent supply called for by the day switch setting, or may be set to interrupt the operation of the day switch and entirely cut off the supply of steam to the radiation at night during certain hours which are selected by the operating engineer.

A morning service switch may operate independently of the day and night switches to supply full steam service to the radiation during the early morning hours (6.00 A.M. to 9.00 A.M.) or afford an excess heat supply when desired by the operator.

Still another form of control regulates the pressure in the mains leaving the boiler plants to correspond with the changes in local factors.

In general practice, the size of a pipe line is fixed so that steam can be delivered to the system at full rated boiler pressure. With a maximum load, the pressure drop in the line will be such that a fixed pressure can be held at a distant point due to definite requirements of the customer. This maximum load is generally fixed by future requirements that may not be reached for years, also the daily and hourly load may vary materially, or the pressure requirements fixing the design may vary at certain periods. Rather than carry full boiler pressure on the system with its corresponding line loss under varying loads, considerable saving can be made by installing one or more pressure-reducing valves in the boiler plant for holding the pressure at a point to correspond with the actual load requirements. In institutional heating these pressure-reducing valves make it possible to reduce the night pressure materially, thereby making a decided saving in coal. Where the load requirements vary considerably, a bank of reducing valves is often installed in multiple, so that the valve in use will be working very close to its rating.

At the present time, the tendency is to distribute at as high a steam pressure as possible, without unduly increasing the cost of the line construction. With standard weight pipe and welded joints, there is no reason why the line should not carry at least 200 lb. pressure at maximum load. With these higher pressures the lines can be kept small, decreasing the investment cost and corresponding line losses.

The reduction in pressure at the boiler plant, together with a considerable drop in the line, will produce a superheating of the steam so that the superheating will balance the line loss and this will make very little, if any, trap drip discharge, thereby eliminating water hammer. Too strong emphasis cannot be placed on the idea of having the distributing lines the right size rather than excessive.

The pipe line can be designed for any grade, but all low points should be drained through traps, discharging to the sewer or to return lines.

The practice of designing a line based on velocity of steam is becoming obsolete in favor of designing for pressure drop.

PIPE LINE EXPANSION

In laying out a pipe line the expansion should be actually determined for each run, and adequate provision should be made for it.

Two methods are in use for taking care of expansion, (1) by some form of expansion joint, and (2) some form of offset or bend.

Table 1 shows the expansion in 100 ft. of pipe at various temperatures. The expansion of any length of pipe is determined by taking the difference

TABLE 1. EXPANSION OF PIPE IN INCHES PER 100 FT.

TEMPERATURE DEG. FAHR.	WROUGHT IRON OR STEEL	CAST IRON	COPPER AND BRASS
0	0.00	0.00	0.00
10	0.08	0.05	0.13
20	0.15	0.10	0.25
30	0.23	0.15	0.35
40	0.30	0.25	0.45
50	0.38	0.36	0.57
100	0.76	0.72	1.14
150	1.15	1.10	1.75
200	1.57	1.50	2.38
250	1.99	1.90	3.02
300	2.47	2.35	3.74
350	2.94	2.80	4.45
400	3.46	3.30	5.24

TABLE 2. FOR LENGTH OF EXPANSION OFFSETS AND BENDS FOR PROPER EXPANSION OF PIPE

TOTAL EXPANSION IN INCHES*	FEET OF PIPE AND OFFSET OR U-BEND FOR DIFFERENT DIAMETERS OF PIPE									
	2″	3″	4″	5″	6″	8″	10″	12″	14″	16″
1	11	13	15	17	19	21	23	25	27	30
2	15	18	21	23	26	29	32	35	38	42
3	18	22	26	29	32	36	40	43	48	52
4	21	26	30	34	37	42	47	50	56	58
5	24	30	34	38	41	47	53	57	63	65
6	27	33	37	41	45	52	58	63	69	71
7	30	36	40	44	48	56	62	68	74	....
8	32	39	43	47	52	60	66	72	....	....

*This column shows the total expansion the offset will take care of without a cold strain. In general these amounts can be increased 40 per cent which increase can be taken up in cold strain of the pipe on being made up.

The length of pipe in the expansion piece should be the same whether in the form of a single right-angle offset or double offset or U-Bend.

The lengths of arms figured for 12,000 lb. per square inch tension for wrought iron pipe. If steel pipe is used this is good for 16,000 lb. per inch so that the arm will take care of ⅓ more expansion.

in expansion at minimum and maximum temperatures and dividing by 100 to arrive at the expansion per foot, then multiplying by the number of feet of pipe for which expansion is to be figured.

In the installation of transmission lines it is frequently the practice to figure on an installation temperature of 70 deg. fahr. and to compensate for about 40 per cent of the total expansion by means of a cold

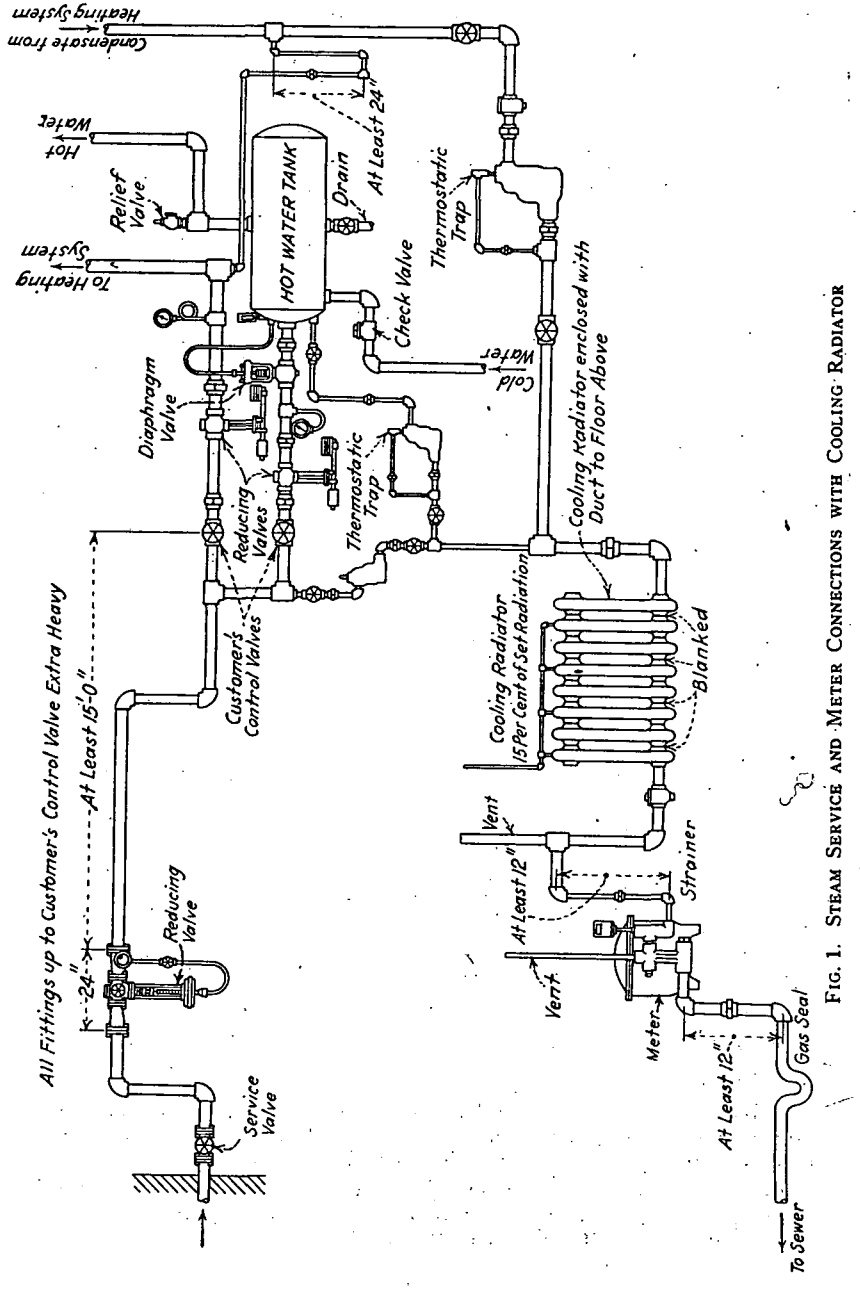


Fig. 1. Steam Service and Meter Connections with Cooling Radiator

Table 3. Capacity of Returns for Underground Distribution Systems in Pounds of Condensate per Hour

Size* of Pipe In.	Pitch of Pipe per 100 Ft.						
	6"	1'	2'	3'	5'	10'	20'
1	448	998	1890	2240	3490	5490	7490
1¼	1740	2490	3990	4880	6480	9480	13500
1½	2700	4190	5740	7480	9480	14500	20900
2	4980	7380	10700	13900	16900	24900	36900
3	13900	22500	30900	37400	50400	74800	105000
4	30900	44800	64800	79700	105000	154000	229000
5	54800	79800	120000	144800	195000	294000	418000
6	90000	138000	187000	237000	312000	449000	.....
8	190000	277000	404000	508000	660000	938000	.....
10	344000	498000	724000	900000	1190000	.....	.....
12	555000	798000	1148000	1499000	1990000	.....	.....

*Size of pipe should be increased if same carries any steam.

Table 4. Steam Requirements of Buildings from Outside Mains in Pounds of Steam per Hour

Sq. Ft. Radiation	Steam Pressure of Service Main Lb. Gage							
	0	10	20	60	100	140	180	200
200	61.8	61.2	60.8	59.8	59.4	59.2	59.0	58.8
400	123.6	122.5	121.6	119.6	118.8	118.4	118.0	118.0
500	154.5	153	152	149.5	148.4	148	147.5	147
750	232	230	228	224	223	222	221	220
1000	309	306	304	299	297	296	295	294
2500	774	765	760	747	743	740	737	735
5000	1545	1530	1520	1495	1485	1480	1475	1470
7500	2320	2300	2280	2240	2230	2220	2210	2200
10000	3090	3060	3040	2990	2970	2960	2950	2940
12500	3865	3820	3800	3740	3720	3700	3690	3680
15000	4640	4590	4560	4480	4460	4440	4420	4410
20000	6180	6120	6080	5980	5940	5920	5900	5880
25000	7740	7650	7600	7470	7430	7400	7375	7350
30000	9290	9180	9120	8970	8910	8890	8850	8830
40000	12380	12250	12160	11960	11880	11840	11800	11780
50000	15450	15300	15200	14950	14850	14800	14740	14700
75000	23200	22800	22800	22400	22300	22200	22100	22000
100000	30900	30600	30400	29900	29700	29600	29500	29400
125000	38650	38300	38000	37400	37200	37000	36900	36800
150000	46400	45900	45600	44800	44600	44400	44250	44100
175000	54200	53600	53200	52300	52000	51800	51600	51400
200000	61800	61200	60800	59800	59400	59200	59000	58900

Each square foot of radiation transmits 250 B.t.u. per hour.

Table for steam entering buildings at stated pressures then reduced to required amount and condensed in radiator to water at 212 deg. fahr. 0 pressure. The above table also allows 20 per cent for piping loss in the building.

strain put in the line at the time of installation. This allows for only 60 per cent of all expansion to be taken care of by expansion joints, offsets or bends.

Table 2 gives the length of pipe that should be made up to provide for the expansion. In general the arms should be made up with pipe bends which can be welded into one continuous length.

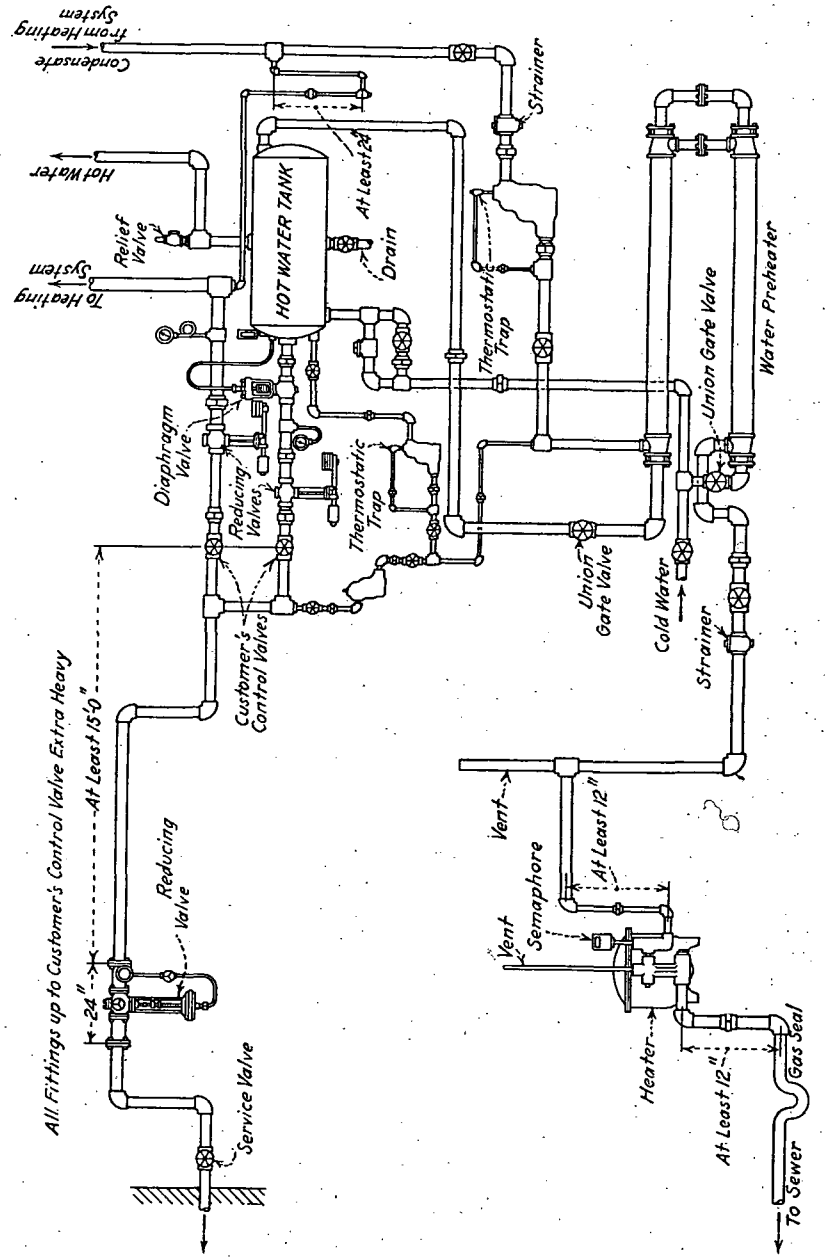


Fig. 2. Steam Service and Meter Connections with Water Preheater

Table 5. Pipe Sizes for Underground Supply Mains Based on a Velocity of 10,000 Ft. per Minute

Gage Pressure Lb.	Lb. Steam per Minute	Total B.t.u. above 200 Deg. Fahr. per Hr.	Pipe Loss B.t.u. per Hour, per Ft. Length		Lb. Steam Condensed per Hour per Ft. Length
			Bare	Covered (10% of Bare)	
1 in. Pipe					
0	2.23	131,100	116	11.6	0.0119
10	3.65	217,200	143	14.3	0.015
20	4.98	298,200	168	16.8	0.0179
40	7.68	461,400	206	20.6	0.0224
60	10.3	627,000	236	23.6	0.0262
80	12.8	780,000	260	26.0	0.0292
100	15.3	936,000	284	28.4	0.0322
120	18.1	1,110,000	304	30.4	0.0349
140	20.6	1,272,000	322	32.2	0.0374
160	23.0	1,416,000	337	33.7	0.0395
180	26.0	1,608,000	355	35.5	0.0420
200	28.5	1,764,000	373	37.3	0.0445
2 in. Pipe					
0	8.70	512,400	209	20.9	0.0216
10	14.2	846,000	258	25.8	0.0270
20	19.4	1,158,000	306	30.6	0.0327
40	29.8	1,794,000	372	37.2	0.0406
60	40.0	2,436,000	426	42.6	0.0472
80	49.7	3,030,000	471	47.1	0.0529
100	59.8	3,660,000	513	51.3	0.0582
120	70.5	4,338,000	548	54.8	0.0631
140	80.4	4,950,000	582	58.2	0.0675
160	89.6	5,520,000	608	60.8	0.0714
180	101.0	6,240,000	641	64.1	0.0760
200	111.0	6,888,000	674	67.4	0.0804
3 in. Pipe					
0	19.2	1,129,200	309	30.9	0.0319
10	31.3	1,860,000	380	38	0.0399
20	42.8	2,562,000	451	45	0.0480
40	65.5	3,588,000	549	55	0.0600
60	87.5	5,280,000	628	63	0.0693
80	108	6,588,000	694	69	0.0775
100	130	7,980,000	756	76	0.0864
120	153	9,420,000	809	81	0.0931
140	174	10,740,000	857	86	0.0999
160	194	11,940,000	897	90	0.1058
180	220	13,560,000	945	94	0.1110
200	240	14,880,000	993	99	0.1180
4 in. Pipe					
0	33.0	1,944,000	397	39.7	0.0404
10	54.0	3,210,000	489	48.9	0.0514
20	73.8	4,422,000	579	57.9	0.0617
40	113	6,840,000	705	70.5	0.0769
60	153	9,300,000	806	80.6	0.0895
80	189	11,520,000	891	89.1	0.1000
100	227	13,920,000	971	97.1	0.110
120	268	16,440,000	1039	103.9	0.119
140	305	18,780,000	1101	110.1	0.128
160	340	21,000,000	1152	115.2	0.135
180	384	23,760,000	1214	121.4	0.144
200	420	25,440,000	1275	127.5	0.152

TABLE 5. PIPE SIZES FOR UNDERGROUND SUPPLY MAINS BASED ON A VELOCITY OF 10,000 FT. PER MINUTE—(*Continued*)

GAGE PRESSURE LB.	LB. STEAM PER MINUTE	TOTAL B.T.U. ABOVE 200 DEG. FAHR. PER HR.	PIPE LOSS B.T.U. PER HOUR, PER FT. LENGTH		LB. STEAM CONDENSED PER HOUR PER FT. LENGTH
			Bare	Covered (10% of Bare)	
		6 in. Pipe			
0	74.6	4,504,000	585	58.5	0.0604
10	122	7,260,000	719	71.9	0.0755
20	167	10,020,000	852	85.2	0.0918
40	256	15,360,000	1037	104	0.1135
60	345	20,880,000	1186	119	0.1320
80	427	26,040,000	1311	131	0.1470
100	514	31,440,000	1428	143	0.1630
120	606	37,260,000	1528	153	0.1760
140	690	42,480,000	1620	162	0.1880
160	770	47,400,000	1694	169	0.1980
180	870	53,700,000	1785	178	0.2110
200	950	58,800,000	1872	187	0.2230
		8 in. Pipe			
0	134	7,980,000	760.7	76.1	0.0785
10	218	12,960,000	936.7	93.7	0.0985
20	298	17,940,000	1109.5	110.9	0.118
40	458	27,540,000	1351	135.1	0.147
60	617	37,560,000	1543	154.3	0.171
80	765	46,680,000	1707	170.7	0.191
100	917	56,160,000	1859	185.9	0.212
120	1080	66,480,000	1988	198.8	0.229
140	1230	75,300,000	2107	210.7	0.244
160	1375	84,600,000	2207	220.7	0.258
180	1550	95,400,000	2325	232.5	0.275
200	1700	105,600,000	2443	244.3	0.291
		10 in. Pipe			
0	211	12,420,000	949	94.9	0.0978
10	345	19,520,000	1170	117.0	0.1230
20	474	28,380,000	1384	138.4	0.1480
40	730	43,860,000	1685	168.5	0.1840
60	983	59,760,000	1927	192.7	0.2130
80	1210	73,800,000	2132	213.2	0.2390
100	1455	89,100,000	2322	232.2	0.264
120	1670	102,600,000	2486	248.6	0.286
140	1960	120,600,000	2635	263.5	0.306
160	2180	134,400,000	2755	275.5	0.323
180	2470	152,400,000	2903	290.3	0.343
200	2700	166,800,000	3051	305.1	0.364
		12 in. Pipe			
0	297	17,460,000	1125	112.5	0.116
10	485	28,860,000	1387	138.7	0.146
20	664	39,900,000	1641	164.1	0.175
40	1020	62,100,000	1999	199.9	0.218
60	1372	83,400,000	2240	224.0	0.248
80	1700	103,800,000	2529	252.9	0.284
100	2040	124,800,000	2753	275.3	0.314
120	2410	148,200,000	2945	294.5	0.340
140	2750	169,200,000	3121	312.1	0.362
160	3060	182,400,000	3266	326.6	0.383
180	3460	213,600,000	3440	344.0	0.406
200	3800	235,200,000	3616	361.6	0.430

The offset lengths which are required for expansion in the case of wrought iron pipe may also be used for brass pipes, using in each case the actual amount of expansion in the piping.

CAPACITY OF RETURNS WITH VARIOUS GRADES

In general, return lines when installed follow the contour of the land and Table 3 gives sizes of return pipes for various grades. It is evident that at points where the grade is great, smaller pipes can be installed.

Table 4 gives the number of pounds of steam condensed to water for various steam pressures which can be used in determining the size of steam main or return line.

Table 5 gives the capacity of various sizes of pipes under various steam velocity of 10,000 ft. per minute. The pipe loss will not vary under other velocities. For other velocities, the capacity may be determined by dividing by 10,000 and multiplying by actual velocity.

HEATING CONDUITS

Conduits for steam pipes buried underground should be water-proof, able to withstand earth loads and take care of the expansion and contraction of the piping without strain or stress on the couplings, also without affecting the installation or conduit. Expansion of the piping must be carefully controlled by means of anchors and expansion joints or bends so that the pipes can never come in contact with the conduit. Anchors can be anchor fittings or U-shaped steel straps which partially encircle the pipes and are firmly bolted to a short length of structural steel set in concrete.

In laying out conduits of this type the following points should be borne in mind:

1. The conduit should be laid out in successive straight runs between manholes or anchor pits.
2. An anchor should be placed wherever the line changes direction.
3. An expansion joint offset or bend should be placed between each two anchors.
4. Manholes should be provided at each expansion joint. Where slip joints are used manholes should be vented.
5. Branches should be taken off at or near an anchor.
6. If the distance between buildings is 150 ft. or less and the steam line contains high-pressure steam, it may be anchored in the basement of one building and allowed to expand into the basement of the second building. If the steam line contains low-pressure steam (up to 4-lb. pressure), this method may be used if buildings are 250 ft. or less apart.
7. If the distance between buildings is between 150 ft. and 300 ft. and the steam line contains high-pressure steam, the lines should be anchored midway between the buildings and allowed to expand into the basements of both buildings. If the steam line contains low-pressure steam this method may be used if buildings are between 250 ft. and 600 ft. apart. No manhole is required at the anchor, and a blind pit is all that is necessary.
8. For longer lines, manholes must be located according to judgment and depending upon the expansion value of the type of expansion joint or bend that is used. The minimum number of manholes will be required when an expansion bend or

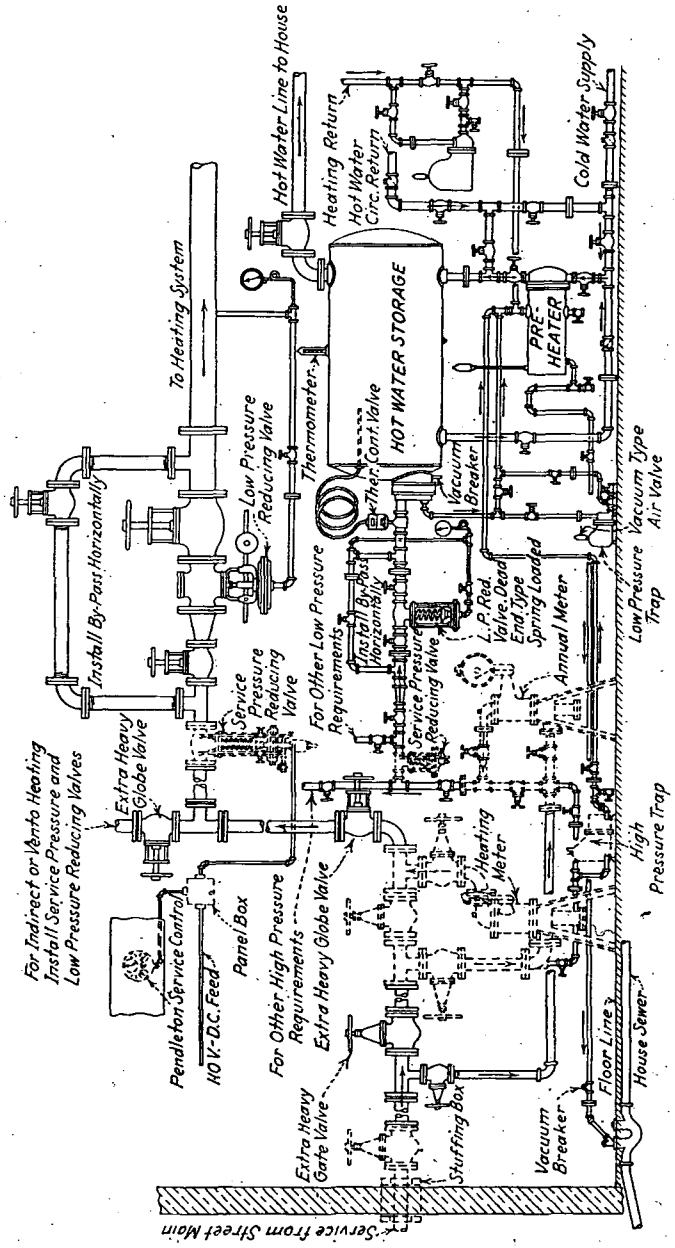


FIG. 3. TYPICAL SERVICE INSTALLATION

an anchor with double expansion joint is placed in each manhole, and the pipes are anchored midway between manholes.

9. Stabilizers to maintain alignment of pipes should be placed on each side of each expansion joint or bend.

10. A proper hydrostatic test should be applied to the piping before the top of the conduit is applied and before application of insulation. The pressure used in this test should be greater than the pressure used in service, and should be not less than 100 lb. per square inch in any case.

The styles and construction of conduits commonly used may be classified as follows:[1]

Filler Type.—The pipes are supported on expansion rollers properly supported from the conduit or independent masonry base. The pipes are protected by a split tile conduit, and the entire space between the pipes and the tile is filled with an insulating filler. Thus the pipes are nested and the insulation between them and the tile effectively prevents circulation of air. The conduit is placed on a bed of gravel or crushed rock from 4 to 6 in. thick, which is extended upward so as to come about 2 in. above the parting lines of the tile. A tile underdrain is placed beneath the conduit throughout the entire length and is connected to sewers or to some other point of free discharge.

Insulated Tile Type.—The insulating material is molded to the inside of a split tile conduit. The pipes are supported on expansion rollers usually. The space between the pipes and the insulating conduit lining may also be filled with an insulating filler. The conduit insulation, piping and earth load are supported by the base drain. A few inches of gravel or crushed rock are placed about the conduit and the base drain.

Sectional Insulation Type (Tile Conduit).—Each pipe is insulated in the usual way with any desired type of sectional pipe insulation over which is placed a standard waterproof jacket with cemented joints. The pipes are enclosed in a split tile conduit which is placed on a bed of crushed rock or gravel from 4 to 6 in. thick. This gravel bed is extended upward so as to come about 2 in. above the parting lines of the tile. Underdrains are sometimes omitted where this type is used, any water which seeps into the conduit being allowed to flow down the bottom of the conduit to the nearest manhole. Drains are laid from the floor of each manhole to some point of free discharge. The pipes are supported on roller frames and these, according to the type of conduit used, are either supported by the conduit itself or have their lower parts set in concrete, thus supporting the pipes independent of the conduit.

Sectional Insulation Type (Tile or Concrete Trench).—A type of construction frequently used in city streets, where service connections are required at frequent intervals, the pipes are insulated as described in the preceding paragraph, and are enclosed in a box or trench made either entirely of concrete, or with concrete bottom and specially constructed tile sides and tops. The pipes are supported on roller frames secured in the concrete.

Sectional Insulation Type (Bituminized Fibre Conduit).—Each pipe is individually insulated and encased in a bituminized fibre conduit. The insulating material is 85 per cent carbonate of magnesia sectional pipe covering, applied in the usual manner as on overhead pipes, except that bands are omitted. After every fifth section of magnesia covering there is applied a short, hollow section of very hard asbestos material in the bottom portion of which rests a grooved-iron plate carrying ball-bearings upon which the pipe rides when expanding or contracting. This short expansion section is of the same outside diameter as the adjacent 85 per cent magnesia covering. Over the pipe covering and expansion device there are placed two layers of bituminized fibre conduit with all joints staggered and the surface of each conduit finished with liquid cement. Conduits are placed on a bed of crushed rock or gravel, approximately 6 in. deep, and this is extended upward to about the center line of the conduit when trench is backfilled. Underdrains leading to points of free discharge are placed in the gravel or crushed rock beds.

[1]For further data on pipe insulation see Chapter XV.

HEATING TUNNELS

Where steam heating lines are installed in tunnels large enough to provide walking space, the pipes are supported by means of hangers or roller frames on brackets or frame racks at the side or sides of the tunnel. The pipes are insulated with sectional pipe insulation over which is placed a sewed on painted canvas jacket or a jacket of asphalt saturated asbestos water-proofing felt. The tunnel itself is usually built of concrete and water-proofed on the outside with membrane water-proofing. Tile drains are installed at each side or in the center below the level of the tunnel floor to prevent the building up of static water pressure on the outside of the construction.

On account of their relatively high first cost as compared with smaller conduits, walking tunnels are sometimes not installed where provision for the heating lines is the only consideration, but only where required to accommodate miscellaneous other services, such as for underground passage between buildings.

STEAM USED PER SQUARE FOOT OF RADIATION PER SEASON

The following factors are used in New York City for the different classes of buildings listed. The factors are based on maintaining for certain hours 70 deg. inside temperature with a minimum of 0 deg. outside and an average of 43 deg. for the heating season, eight months, October 1 to June 1. In this group are six types of buildings:

For manufacturing or commercial loft type, where steam is used to heat the premises during the day hours to maintain 65 to 68 deg. from 9 A.M. to 5 P.M. No Sunday or holiday use and no night use. *Factor:* 325 lb. per square foot of radiation per season.

For office buildings using steam during daylight hours only to maintain 70 deg. from 9 A.M. to 6 P.M. for approximately 240 days (heating season). No night use. *Factor:* 400 lb. per square foot of radiation per season.

For office buildings using steam during day hours and at night when required to 7, 8 and 9 P.M. (customary where there are stock brokers or banking offices (204 days. *Factor:* 500 lb. per square foot of radiation per season.

For residences of the block type (not detached) where high class heating service is required somewhat similar to apartment buildings. *Factor:* 550 lb. per square foot of radiation per season.

For apartment houses where high class heating service is required. (Steam off at midnight). *Factor:* 650 lb. per square foot of radiation per season.

For hotels (commercial type) where very high class service is required—24-hour service. *Factor:* 800 lb. per square foot of radiation per season.

By assuming 1 sq. ft. of direct low-pressure steam radiation equivalent or required for each 100 cu. ft. of space heated, which seems a fair ratio in New York City, it is possible to roughly estimate the steam required per cubic foot of space which is often more easily obtained than the radiation.

Considerable additional data on the heating requirements of various types of buildings in a number of cities may be found in the section on Utilization in the Handbook of the *National District Heating Association*.

CHAPTER XII

GREENHOUSE HEATING SYSTEMS

Temperatures Required, Steam Heating Systems, Hot Water Radiation, Location of Radiation, Air Circulation.

A GLASS structure for horticultural purposes owing to the manner of its construction and the materials employed, offers less resistance to the penetration of frost and cold winds, than many other kinds of buildings and necessarily requires a proportionally greater amount and a more even distribution of heat.

The heating apparatus must be so arranged as to diffuse an even heat throughout every part of the house, and must be of sufficient heating power to increase the heat quickly in case of sudden changes in the weather, and so maintain the desired temperature during the night.

The temperatures usually required depends on the class of vegetation to be grown and are given in Table 1.

Although the same tables, formulae and other data that are used to estimate the heating requirements of systems in the usual types of buildings are also applicable to greenhouse heating and although the same pumps, traps, regulators, valves and other devices and fittings are used in greenhouses as in other systems, there are many differences that must be kept in mind so that due allowances may be made in the specification of a heating plant.

For instance—the highest temperatures in greenhouses are required at night, whereas with most other systems the maximum temperatures are required in the day time.

Greenhouse fires are banked almost always during the day throughout the firing season, even in mid-winter when the sun is shining; this in marked contrast to practically all other types of heating systems where the fires are banked at night.

Greenhouse radiation is almost exclusively made up of piping. The temperature demands are almost always below 70 deg. and horizontal piping carries a higher coefficient of emission than the radiating surfaces used in other systems. Special care must, therefore, be given to the selection of the boiler; the demands on it will be higher than with other forms of radiation.

Long runs of pipe are used and expansion and contraction require more consideration than in house-heating work; piping must be tied up, anchored, installations must be flexible. Although expansion joints are no more desirable in greenhouse heating than elsewhere, expansion must be compensated for by "spring" of pipe and by swivel fitted joints,

Material for this Chapter prepared for THE GUIDE by G. T. Cornwall.

expansion joints being used where expansion may not be compensated otherwise.

The height of the heating coils above the boiler affects the design and proportion of the heating mains. In many greenhouses the coils are not more than 1 ft. 6 in. above the top of boiler and the arrangement of the greenhouse doors necessitates some of the coils being much shorter than others. In this case special care is necessary to avoid short circuiting or interference with the circulation of the water in the longer coils.

TABLE 1. USUAL TEMPERATURES REQUIRED IN GREENHOUSES

KIND OF VEGETATION	TEMPERATURE REQUIRED, DEG. FAHR.
Violets	40 to 45
Camelias	
Azaleas	
Lettuce	
Cool Palm Houses	50 to 55
Carnations	
General Purposes	55 to 60
Roses	
Mushrooms	
Forcing Houses	60 to 65
Conservatories	
Orchid Houses	
Fern Houses	
Peach House	65 to 70
Vinery	
Early Tomatoes and Cucumbers	
Tropical Palm House	

Private greenhouses and medium size commercial greenhouses are mostly heated by hot water, and the large commercial houses by steam.

The radiation is made up of coils of pipe placed along the outside walls and under the benches.

Twenty or twenty-five years ago, it was customary to use 3 or 3½ in. pipe for the hot-water heating coils as the large water contents of this size pipe maintained a steady temperature in the houses where there was no night fireman and the gardener gave no attention to the fire during the night.

Now, most commercial houses where hot-water heat is used, the heating coils consist of 2 in. wrought iron or steel pipe. This smaller size holding much less water per square foot of radiation than the larger sizes, enables the fireman to raise the temperature of the house much quicker than when larger size pipe is used, and when the sun shines the house can be cooled off much quicker which is often desirable.

For small houses and long firing periods 3½ in. pipe is best.

To proportion the amount of hot-water radiation required for a green-

TABLE 2. FACTORS FOR ESTIMATING HOT WATER RADIATION FOR GREENHOUSES

For 70 to 75 deg. divide square feet of glass and equivalent by	2.00
65 " 70 " " " " " " " " "	2.28
60 " 65 " " " " " " " " "	2.62
55 " 60 " " " " " " " " "	3.00
50 " 55 " " " " " " " " "	3.46
45 " 50 " " " " " " " " "	4.00
40 " 45 " " " " " " " " "	4.67
35 " 40 " " " " " " " " "	5.50

house, it is almost impossible to figure the air leakage through the laps of the glass. This is not of any importance, however, for in cold weather these laps freeze and seal tight. Those that have had years of experience and specializing in greenhouse heating consider the exposed glass surface and its equivalent only and can guarantee a specified temperature by dividing the exposed glass and its equivalent by the factors in Table 2, which are based on the mean temperature of the water in the coils at 150 deg. and temperature outside at zero.

Greenhouses do not respond to figures in various ways: Two greenhouses covering the same amount of ground surface may be quite different in square feet of exposed glass surface. The workmanship, quality of glass, and exposure to prevailing cold winds must be taken into consideration. The humid atmosphere of greenhouses—and for some purposes the atmosphere is much more humid than for others, as for instance, for rose growing—at some temperatures causes the laps to seal with condensation, thus checking, or stopping the air loss through the laps. At lower temperatures, these laps are sealed with ice and at still lower temperatures, the inside surface of the glass is entirely frosted over so that its conductivity is changed. It may be much more difficult to heat a greenhouse at 15 to 25 deg. above zero with the wind blowing, than at zero or below, because the low temperature house may be sealed with ice, as stated.

Table 2 gives the factors for dividing the square feet of glass and equivalent in order to determine the square feet of hot-water radiation required in horizontal pipe coils. These are based on average water temperature of 150 deg. fahr., a temperature in flow mains of 180 deg. fahr. and outside temperature of 0 deg. fahr.

If the house is to be heated by 1¼ in. steam coils use the same divisors as given by Table 2, and the results will give lineal feet of 1¼ in. pipe coil required. (not square feet of radiation.)

TABLE 3. FACTORS TO MULTIPLY FIGURES OBTAINED FROM TABLE 2 TO DETERMINE SQUARE FEET OF HOT WATER RADIATION FOR OTHER THAN 0 DEG. OUTSIDE TEMPERATURES

5 deg. above 0	0.92	5 deg. below 0	1.06
10 " " 0	0.84	10 " " 0	1.15
15 " " 0	0.75	15 " " 0	1.24
20 " " 0	0.66	20 " " 0	1.33
25 " " 0	0.58	25 " " 0	1.42
30 " " 0	0.50	30 " " 0	1.05
		35 " " 0	1.58
		40 " " 0	1.63

Tables 1 and 2 are based on the house being of ordinary sound construction and tightly glazed with double thick glass.

POSITION OF RADIATION

Greenhouses are piped in all sorts of ways to suit the great number of different ideas of greenhouse owners and operators; the location and arrangement of the piping are governed largely by the plant bench or plant bed arrangement, suiting the special requirements of the plants or flowers to be grown in the houses. In houses for vegetable growing, where planting is directly on the floor of the greenhouse, piping should be mainly, and if possible, entirely, on the sides so as to provide the maximum growing surface. For rose growing the piping should be more scattered or distributed than for any other purpose—if there are raised benches, some heating surface must be under every bench; if there are solid beds, some radiating surface must be in every walk.

The bulk of the piping for all purposes, however, should be on the side walls, or just inside the outer walls of the greenhouse. For sweet pea growing, most of the pipe surface should be on the side walls and some on the pipe columns, generally high enough to permit walking under. There is much latitude, however, in the placing of pipe coils.

AIR CIRCULATION

Recent experience shows that proper air circulation and conditioning greatly accelerates the growth of most plants and also prevents the growth of spores and moulds. This is accomplished by the use of proper mechanical apparatus for supplying and exhausting the air and for controlling its temperature and humidity.

CHAPTER XIII

DOMESTIC AND INDUSTRIAL OIL BURNING

Data on Fuel Oils, Types of Burners, Automatic Control, Installation Data, Costs to Operate, Domestic Heating, Industrial Heating.

IT is the purpose of this chapter to give the essential data on the equipment and methods to be employed in the use of oil as a fuel for heating and industrial services.

There is claimed for liquid fuel, the advantages of space for storage, simplicity in location of storage adjacent to boilers and means of transportation from the remote points of storage to boiler, reduction in labor and handling of fuel, the elimination of ash removal, ease of control of furnace temperatures, and the elimination of the expense of banked fires. Each case, however, where the liquid fuel is contemplated, will have, of necessity, to stand on its merit. The operating cost both with oil and other fuels must be figured and the user will have to evaluate the extra convenience, after which a decision can be made as to what type of fuel should be used.

In the selection of burner equipment and in the determination of storage facilities, it is well to decide what grade of oil is to be used, its Baume' gravity, viscosity, flash point, and cold test, or temperature at which it will cease to be fluid.

The uniform fuel oil specifications of the *American Oil Burner Association* classify fuel oils according to Table 1.

The furnace oils are used primarily for domestic purposes and do not require pre-heating. The fuel oils with the exception of No. 4 are viscous at normal temperatures and require pre-heating for satisfactory operation. For commercial oil burning oil No. 6 is used when available because of its higher heat content and lower price. Installations for the heavy oil and the labor to operate cost more than those for furnace oils but the lower price and higher heat contents frequently justify their use.

Fig. 1 gives the heat contents of various quality oils, per pound and per gallon.

DOMESTIC OIL HEATING

With the large number of domestic oil heating units that are available, it is important to look into the construction of the burner as to design, workmanship and materials, but one of the most important points to be kept in mind is the ability of the man making the installation and adjusting the burner to meet the needs of each application and to give the proper service to the installation. Further considerations in making a choice are the adaptability of the particular burner to the boiler, its

Material for this Chapter prepared especially for THE GUIDE by Harry F. Tapp and W. F. Goodnow.

ability to satisfactorily burn the fuel that is available in a given locality, and its quietness of operation.

DOMESTIC FUEL OILS

Furnace oils, Nos. 1 to 3, are those used for domestic heating installations as they are available in most territories and they do not require pre-heating. They are suitable for installations requiring up to 15 gal. per hour, or more, in districts where heavy oil is not available. Burners should be selected that will satisfactorily handle the grade of oil available and owners should be advised to employ only the grade of fuel for which the burner is designed, except that a lighter grade than the one specified, can be used in most any type of burner.

BURNER TYPES AND CHARACTERISTICS

There are two distinct types of oil burners used for oil heating—the natural draft burner and the mechanical draft burner. Their names indicate the manner in which the air for combustion is obtained.

The natural draft burner requires no motor and usually has no moving parts. The air for combustion is supplied by the pull of the chimney and is, therefore, dependent upon the construction of the latter. This type of burner is often incorrectly referred to as a "gravity" type burner. Gravity indicates the manner in which the fuel is fed to the burner and a gravity system is applicable to either natural draft or mechanical draft burners. This type of burner is more susceptible to changes in the weather, wind currents about the chimney and other factors which cause a variation in the draft intensity than is the mechanical draft burner, unless the effects of this variation in draft can be overcome in the design of the chimney, or in the design of the burner, or by the use of a draft regulator. A natural draft burner is usually limited to small heating loads, depending in size somewhat on the design of burner, and for best operation requires the use of lighter oils. It has in its favor a low first cost, simplicity of design, noiseless operation and requires no power for operation.

The mechanical draft burner is motor driven and often the air for combustion is supplied by a fan or blower. Generally where a fan is used it is of sufficient capacity to supply the entire amount of air for combustion when the burner is operating at its maximum capacity. Often where a blower, either centrifugal or positive pressure, is used, only a portion of the air required is supplied under pressure, the balance being induced by the injector action of the air from the blower plus the natural draft from

TABLE 1. FUEL OIL SPECIFICATIONS
(*A.O.B.A.* Standard)

OIL NO.	NAME	APPROXIMATE GRAVITY RANGE BAUME
1	Furnace Oil Light	(36° – 40°)
2	Furnace Oil—Medium	(32° – 36°)
3	Furnace Oil—Heavy	(28°–32° and 25° Pacific Coast Diesel Oil)
4	Fuel Oil—Light	24°+
5	Fuel Oil—Medium	18°+
6	Fuel Oil—Heavy	14°+

the chimney. The air from the blower is usually used to aid in the atomization of the fuel. The fan or blower produces a more constant

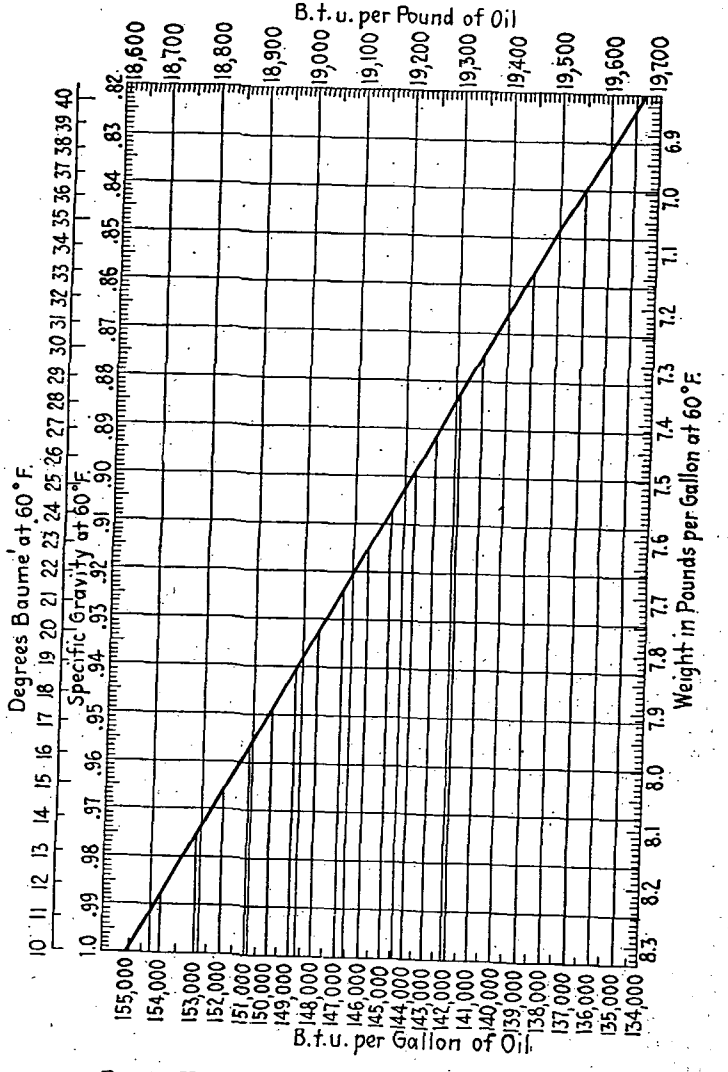


FIG. 1. HEAT CONTENT OF VARIOUS QUALITY OILS

supply of air under varying draft conditions and therefore maintains a uniformly efficient combustion condition.

Another classification of burners used is with reference to the means employed to prepare the fuel for combustion. The terms are vaporizing and atomizing burners.

In the vaporizing burner the fuel is prepared for combustion by the addition of heat. The heat serves to convert the liquid fuel into a vapor which is mixed with the air for combustion either just before or during the combustion process. Blue flame combustion is sometimes advocated but as a blue flame radiates very little heat it is of no particular advantage in a boiler or furnace that has been designed for coal burning, wherein the major heat transfer is secured through radiation. By vaporizing the fuel, moving parts can be eliminated and it is easy to control at low combustion rates. However it requires a light fuel for best results and with poor design there is the possibility of carbon trouble due to "cracking" or decomposition of the oil in the vaporizing chamber.

In the atomizing burner the fuel is broken into a fine mist which is mixed with the air for combustion either just before or progressively during the combustion process. The particles are so fine that they are quickly vaporized by the heat of combustion and if properly mixed with sufficient air will burn with a clean hot flame. There are many ways to atomize oil—under pressure through a small orifice, by compressed air or steam, by centrifugal force from the edge of a rapidly rotating cup or disc and numerous other equally effective methods. Any of the methods used will break the oil into very fine particles and when applied with intelligence will give satisfactory results. With the atomizing type of burner cheaper oils may be utilized; they will start readily from a cold condition and can be applied to installations requiring a high fuel consumption.

The perceptible sound incident to the combustion of oil is dependent largely upon the means employed to mix the oil and air and the rate of B.t.u. liberation per unit of combustion volume. It is obvious that this characteristic can be controlled to some degree by the design of the burner and the method of application to the combustion chamber of the boiler. A further controllable factor is the amount of mechanical sound; this will vary with design, mechanical condition and the adjustment of the unit. The transmission of both mechanical and combustion sounds can be governed to some extent by the utilization of some means to absorb vibration.

IGNITION SYSTEMS

In most natural draft burners the oil is lighted manually with a torch through the fire door, although some of them are provided with a gas, electric or oil pilot, at the option of the owner. Full automatic burners are ignited with either an electric spark from a high tension transformer or from a gas pilot light. This gas pilot, in some designs, burns constantly while in others a combination of the electric and the gas system is used, the spark igniting the gas and the gas flame igniting the oil. The type of ignition system used is dependent to some extent upon the design of the burner and upon the personal opinion of the designer. Several burners are being designed so as to make the means for ignition optional with the purchaser. Where gas is used the application of the

burner may be limited to a territory having a gas supply although it can be used with gas supplied in containers. Under average conditions the cost of ignition with gas is slightly greater than with electricity.

AUTOMATIC BURNER CONTROLS

There are two systems of control instruments. The low voltage (15–20 volts) and the high voltage (110 or 220 volts). Both systems are used with complete satisfaction.

A room thermostat is used to indicate the temperature of the room and to control the operation of the burner so as to maintain the desired temperature between limits of plus or minus 2 deg. This instrument is mechanically accurate and will function according to the temperature conditions of its location. Therefore, it should be located with care. Most people prefer to have it located in the living-room. It should be on an inside wall about 5 ft. from the floor at the breathing level, protected from abnormal drafts such as stairways, or entrances; it should not be placed near chimney, radiators, registers, hot-water or steam pipes or other sources of heat. Special care should be taken to avoid concealed steam or hot-water pipes. Another important factor in maintaining a satisfactory uniform heating throughout the house, which cannot be controlled by the thermostat is the matter of installed radiation. It is important that the radiation be carefully proportioned so that when the desired temperature is reached in the room where the thermostat is located the same temperature will have been reached in all of the rooms of the house.

Apparatus is also usually provided to control the operation of the burner so as to prevent overheating of the boiler or furnace; in case of a steam boiler to prevent the development of abnormal pressures, and in case of a hot-water boiler to prevent too high a water temperature.

Control devices are sometimes added for keeping the temperature of the water in steam boiler below the boiling point during the Summer, so that the same boiler may be used for continuing the domestic hot-water service throughout the Summer without sending steam to the heating system. Such a device is, of course, switched off in the Winter. A safety control is provided to establish a time limit within which the oil must be ignited every time the burner is started and to shut the burner down if for any reason the ignition does not take place or if there is a cessation of combustion. Nearly all of the burners use standard control instruments which in some cases are modified to meet some peculiarity of the design. The majority of the burners operate on the intermittent system, but there are a few that operate on a system known as the high-low, where the burner is continuously operating, the flame intensity being varied to meet the temperature variation as indicated by the thermostat. There is considerable discussion among designing engineers as to the relative merits of the two systems but as the high-low may have a slight advantage during the coldest weather, the intermittent burner will be more economical during the milder weather, so that over the entire heating season, the total amount of fuel used will be very nearly the same.

BURNER INSTALLATIONS

Most burners are installed in boilers designed for coal and the results in most cases are quite satisfactory. Where a boiler is being purchased for use with oil heating equipment care should be taken to select a boiler that has long flue passes, that do not short circuit the gases from the combustion chamber to the flue. There are several boilers that have been designed especially for oil burning that are very efficient and economical. All oil fuel boilers should be provided with automatic feed water regulator or low water cut-off as the boiler is often neglected on account of the automatic features eliminating the necessity of a daily inspection.

Although slightly less draft is required for oil heating equipment than is required for coal fires and a smaller chimney area would be satisfactory, it is recommended that the chimney be designed to meet the boiler manufacturers' requirements as specified for coal burning. It is preferable to have the oil burner flue isolated from other flues as this may be helpful in preventing any mechanical sound from being transmitted to the rooms of the house. A well designed chimney that will insure uniform draft conditions is just as important to an oil burner as it is to a coal fired heating plant.

With many of the cast-iron water-tube sectional boilers it has been found possible to increase their rating to some extent by using oil as a fuel. This increase amounts to from 10 to 25 per cent, but boiler equipment should not be selected on this basis without the knowledge and approval of the boiler manufacturer. This increase in rating is usually not possible with round boilers. Where round boilers are used with oil heating equipment it is best to select a boiler that has extra indirect heating surface in the form of intermediate sections.

In applying oil heating equipment to existing coal burning boilers it is often advisable to baffle the passes in order to increase the travel of the hot flue gases and also to keep them in closer contact with the heating surface. In fire-tube boilers it is often desirable to use retarders inserted in the tubes so as to give the flue gases a spiral motion and keep them in contact with the surface of the tube.

For warm-air installations a furnace of welded construction should be selected as it is more suitable for the conditions imposed by oil heating and will require less attention. Cast-iron sectional furnaces will give satisfactory results if care is taken to insure tight joints and a careful inspection made each year.

For domestic hot-water supply a steam coil heater is quite satisfactory with steam or vapor and, with suitable controls on the hot-water tank, can be used the year round at a very reasonable cost. An iron shell type of heater with local hot-water circulating lines between the shell and the water of the boiler and with a copper coil in the shell, through which the water in passing is heated, is very satisfactory with either steam or hot-water boiler, but care must be taken to have such heaters of ample capacity and connected to ample size storage tanks, especially with hot-water boilers. This system may also be very successfully used the year around if an automatic control such as described under "Automatic

Burner Control" is used. Small size burners are made that are suitable for installing under small hot-water heaters and operating automatically from a control on the hot-water tank. A coil in the combustion chamber is not generally satisfactory.

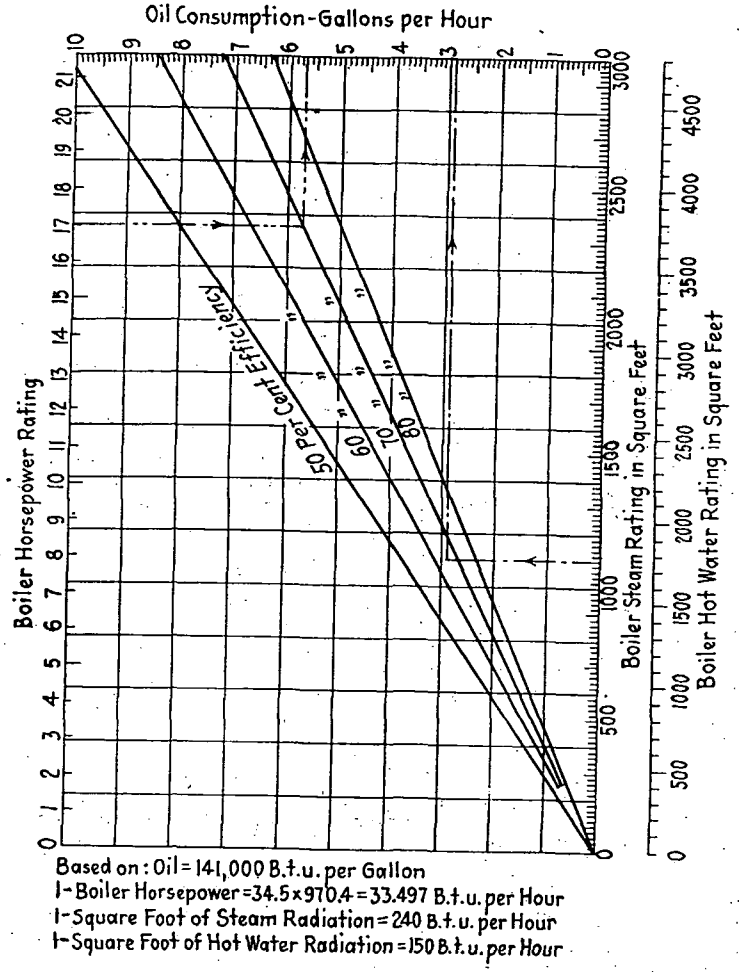


FIG. 2. FULL LOAD RATE OF OIL CONSUMPTION FOR HEATING BOILERS.

Installations should always be made by trained men under the direction of the burner manufacturer as every burner has peculiarities that should be given consideration when the installation is made. It is also important that the burner should be correctly adjusted for each instal-

lation as a greater loss in efficiency often results from poor adjustment rather than from poor design. A burner should have sufficient capacity to develop full rating of the boiler and it is preferable that it have some excess; it should also be adjustable over a range from 50 to 100 per cent rating, see Fig. 2. The flame adjustment is best determined by a flue gas analysis but a good check can be made by noting the color of the flame. A white flame indicates excess air or insufficient oil, a red smoky flame insufficient air or excess oil, and an orange flame just tipped with red indicates an efficient and clean combustion. The boiler room should be well ventilated so that the burner can obtain an adequate supply of fresh air at all times.

Burner and tank installation and all electrical work should be installed in accordance with local ordinances. If no local rules are in force the rules recommended by the *National Board of Fire Underwriters* should be followed.

TANK INSTALLATIONS

Tank installation should always be made in accordance with local regulation but usually inside exposed tanks are permitted where the maximum capacity does not exceed 275 gal. This amount may be fed to the burner by gravity if desired and proper precautions are taken to prevent an abnormal flow of oil. These tanks should be installed on non-combustible supports and located at least 10 ft. from the boiler. A very desirable installation is with an outside buried tank, of at least 1100 gal. capacity, preferably located below the level of the burner. Where this is impractical some means must be used to prevent syphoning of the oil from the tank in case of a break in the fuel supply line. There are several devices of this nature approved by the Underwriters' Laboratory. The use of a large tank eliminates the necessity of watching the fuel supply and will often permit fuel to be purchased at a price enough lower to pay for the difference in installation cost. All tanks should be provided with a direct reading gage which gives a constant check on the amount of fuel on hand. Tanks should be located so that the fill line is near the drive or curb so as to facilitate delivery from the tank truck.

CHIMNEY DESIGN

Although slightly less draft is required for oil heating equipment than is required for coal fires and a smaller chimney area would be satisfactory it is recommended that the chimney be designed to meet the boiler manufacturer's requirements as specified for coal burning. It is preferable to have the oil burner flue isolated from other flues as this may be helpful in preventing any mechanical sound from being transmitted to the rooms of the house. A well designed chimney that will insure uniform draft conditions is just as important to an oil burner as it is to a coal fired heating plant. For further data on Chimneys, see Chapter VI.

COMPARATIVE COSTS

Comparative cost figures for various fuels depend entirely upon the heat content of each fuel and the efficiency with which each is utilized.

With oil it is reasonable to assume an increase in efficiency of 10 to 15 per cent over coal. Charts shown in Fig. 3 and 4 gives comparative

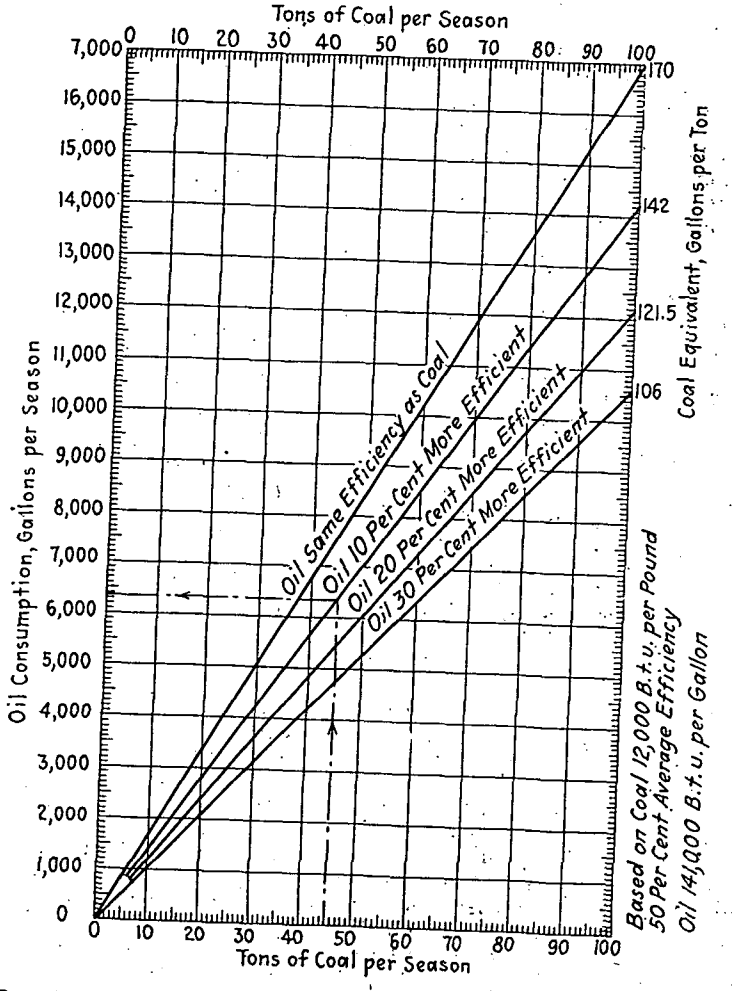


FIG. 3. OIL CONSUMPTION PER SEASON AS COMPARED WITH CONSUMPTION, FOR HEATING

consumption of oil against seasonal coal or gas requirements. These figures are based on an oil containing 141,000 B.t.u. per gallon. By referring to Fig. 2, these figures can be corrected for other grades of oil.

INDUSTRIAL OIL BURNING

Burners

Atomizing burners are used exclusively for installations with heavy oil. Of these, there are three types: steam atomizing burners, air atomizing burners and mechanical atomizing burners.

The steam atomizing burner has two classifications, the outside mixing and the inside mixing type. With the outside mixing type, the oil is forced through an orifice at a comparatively low-pressure and just as it emerges from this orifice it is struck by a jet of steam traveling at a high velocity from a direction at right angles with the flow of oil. The steam jet breaks the oil and injects it into the combustion chamber in a fine spray or mist. The inside mixing type has a turbulence mixing chamber between the steam orifice and the burner opening. The mixing inside the burner permits some vaporization of the lighter hydrocarbons from the heat in the steam so that the mixture issuing from the burner opening lights readily and maintains a steady burning flame. Steam burners require from 1.5 to 5 per cent of the total steam generated for atomization; 2 to 2.5 per cent being a good average. This average can be easily maintained by correct adjustment of the burners. For the best results the steam should be dry.

Air atomizing burners using high-pressure air are similar in design to those using steam. This type is not used as much as low-pressure air burners. Ordinarily, high-pressure air burners are used where a supply of compressed air is available. Low-pressure air burners use comparatively large volumes of air under pressure of 1½ to 2½ lb. per square inch. Air atomizing burners are efficient and if the blowers or compressors supplying the air are steam driven, they will require approximately 2 ½ to 3 per cent of the steam generated for the motive power, but the exhaust steam is available for use in the pre-heaters, so that the steam consumption compares very favorably with steam atomizing burners. The first cost, however, is greater with air atomization than with steam atomization.

Mechanical atomizing burners are those which atomize the oil without the aid of air or steam, although it is common practice to use air under low-pressure in connection with mechanical atomizers to further atomize the fuel but this is not essential. The high-pressure atomizer forces the oil through the small orifice under high pressures (100 to 200 lb. per square inch). The oil is given a rotary motion by slots cut tangentially to the diameter of the orifice of the burner, so that the centrifugal force of the oil leaving the orifice acts as an aid in atomizing the fuel. Another type of mechanical burner is the rotary cup burner. In some burners the cup is positively driven by an electric motor or steam turbine and has a fan mounted on the same shaft so as to provide a portion of the air for combustion under pressure to aid in the atomization of the oil as it leaves the edge of the rotating cup. Another type of rotary cup burner has the cup driven by an air turbine utilizing the velocity of low-pressure air from a centrifugal blower. This blower is usually located at a remote point from the boiler and is of sufficient capacity to supply all of the burners in the battery, although there are some installations where each burner has its own individual blower. While the first cost of mechanical atomizing burners is usually comparatively high, they have the advan-

tage of returning all the steam used for pumping for heating the boiler feed water. Further advantages of this type are simplicity and economical operation with uniform combustion regulation.

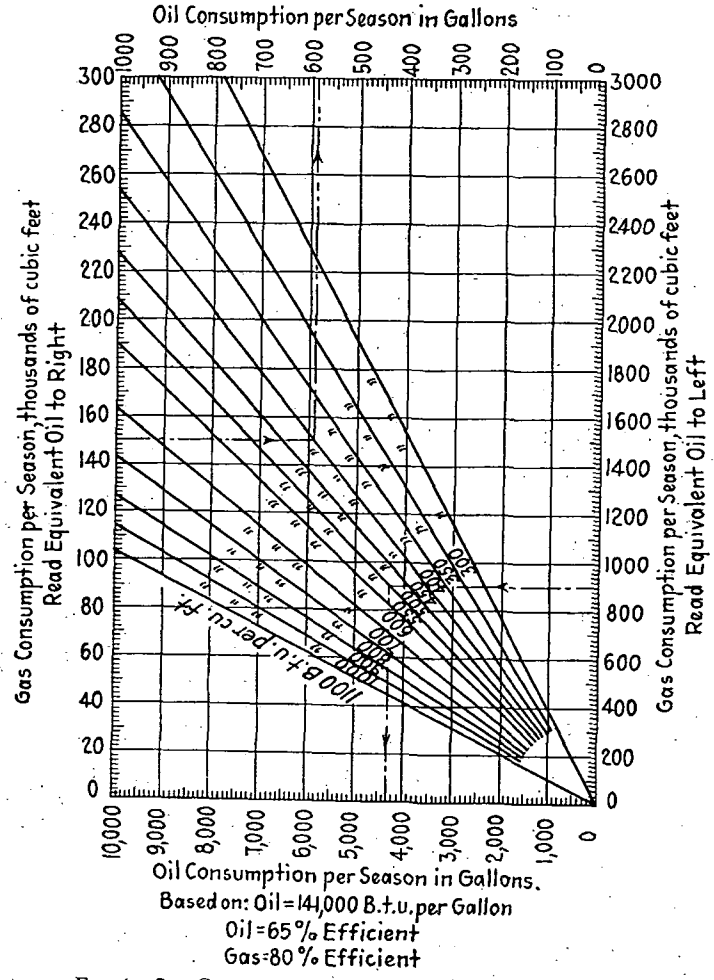


FIG. 4. OIL CONSUMPTION PER SEASON AS COMPARED WITH GAS CONSUMPTION, FOR HEATING

Burners for commercial installations are usually manually operated although they have semi-automatic controls which vary the amount of air and oil as the load fluctuates.

For some burners, the air for combustion is partially supplied from a

blower and is used to aid in the atomization of the fuel, the balance being induced by the natural draft through openings in the refractory hearth of the combustion chamber. These openings are usually arranged to conform to the shape of the flame from the burner so that the air comes in contact with burning fuel and is not permitted to escape unused through the boiler passages and up the stack. With other burners there is an air register, designed as part of the burner which admits the air by natural draft through adjustable vanes, giving a rotating motion to the air as it enters the combustion chamber about the atomizer. Some installations are provided with forced draft by connecting the air register to a duct from a fan blower.

There are many factors that should be taken into consideration when selecting burners for application to a particular installation. A good burner should be flexible in its adjustments, it should be easily adjusted over a considerable capacity range, it should be suitable for the lowest grade of oil that will be used, and its design should permit the shaping of the resulting flame from the burner so that the flame will fit the combustion chamber closely. A flame that does not properly fit the shape of the combustion chamber permits air to escape around the flame without mixing with the fuel and is therefore responsible for inefficient combustion results. If possible, it is best to use a single burner, rather than burners in multiple, wherever the shape of the flame can be adjusted to meet the combustion chamber requirements and the burner has sufficient capacity and flexibility to meet the variable loads imposed on the boiler. Single burners ordinarily meet the requirements of buildings such as schools, theatres, churches and apartments. For large office and commercial buildings the boilers are usually of such size as to require two or more burners per boiler in order to obtain the required flame application and flexibility of control.

Draft

There are several reasons why less draft is required with oil burning equipment than is necessary where coal is used as a fuel. The principle reasons are that the draft loss through the fuel bed and grate is eliminated, and as a general rule the stack temperatures are lower and the volume of gas less than with coal. For this reason the cross-sectional area of the stack may be smaller, some authorities say that it may be safely assumed as 60 per cent of the area that would be furnished for an equivalent coal fire boiler. In determining the height of the stack, care should be taken to design a stack that will give sufficient draft for the maximum requirements of the boiler and no more. It is therefore advisable to follow the recommendations of the boiler manufacturer and if possible the burner manufacturer should also be consulted so that the air register or parts can be designed correctly for the available draft, and in this way provide for sufficient air to develop the rating of the boiler in the combustion volume available.

Furnace

Under average conditions the combustion volume should be such that a release of 40,000 B.t.u. per cubic foot per hour would not be exceeded at 100 per cent of the boiler rating. This is not the maximum B.t.u. release possible but it is representative of good practice.

Where oil burning equipment is applied to existing coal burning boilers excess draft can be corrected by using a damper. It is also advisable in many cases to use baffles to provide for a longer flue travel and in fire-tube boilers it is good practice to insert retarders in the tubes which give the flue gases a spiral motion and keep them in contact with the surface of the tube.

Auxiliary Apparatus

Regardless of the type of burner used, the installation of the oil system, which includes the tank, heaters, strainers, pumps and piping, is important.

Tanks should be installed in accordance with the local rules for the storage of oil fuel, but in the absence of local regulations, it is suggested that the rules and regulations of the *National Board of Fire Underwriters* be followed. The size of the storage tank is often governed by the amount of space available but it is a question that should be given due consideration, taking into account the time required for delivery, the daily fuel requirements, also the price in various quantities. Where purchases are to be made by carloads it is advisable to have at least a 15,000 gal. tank.

While oil consumption cannot be checked by gaging the tank, an oil meter is the best means of readily determining fuel consumption. It is recommended, however, that each storage tank be equipped with a gage in order to have a constant check of the oil on hand.

A small heater is usually installed in the storage tank around the suction inlet. This heater is used to reduce the viscosity of the oil so that it can be readily pumped. The oil heaters are usually steam coils, but some local regulations require that this heating be done by hot water only. The oil is delivered from the pump to the supply line for the burners and is passed through larger heaters where the temperature is raised to a point that insures the viscosity being low enough for atomization. This temperature is variable for different oils but will usually be between 150 and 200 deg. fahr. It is important that oil be kept at a uniform temperature for satisfactory atomization. This is done by means of automatic temperature regulators which open and close the steam supply valve to the heater coils. From the heaters the oil is delivered as directly as possible to the burners for atomization.

As all fuel oils contain a certain amount of foreign matter in suspension, it is important that the oil line have large strainers with sufficient screen area to permit their being used for some period of time without the screens becoming clogged and preventing the flow of oil. The best practice calls for strainers in duplicate on the suction side of the pump and additional strainers, known as discharge oil strainers, on the delivery side of the pump. It is important that strainers be located where they are readily accessible for cleaning. For small commercial installations, the oil pumps are usually of the rotary type driven by electric motors and are sometimes incorporated into the design of the burner. For large installations, steam operated piston type pumps are commonly used. It is recommended that pumps and heaters be installed in duplicate. This is required by some local regulations where the boiler service is used in connection with the fire protection apparatus.

With the various types of burners that are being used, there have

been developed systems which differ in their construction and arrangement of piping, pumping and tank equipment. One of the most widely used oil systems at the present time is the continuous circulation system. In this system, the oil is pumped from the tank by the oil pump and is delivered to the burner supply line; any excess oil is by-passed through a regulating valve back to the tank or to the suction side of the oil pump. In this way the proper atomizing temperature of the oil is maintained and choking or accumulation of sediment in the supply line is avoided. In the layout of the piping for pre-heated oils it is important to keep the oil supply pipe below the level of the burner and without traps to prevent the formation of vapor pockets which are liable to shut off the fuel supply or cause irregular operation.

CHAPTER XIV

HEATING WITH GAS

Data on Gas Fired Boilers and Furnaces, Space Heaters, Combustion and Heat Values, Installation Data, Costs to Operate, Conversions.

USING gas for building heating purposes does not bring in any new heating problems. The only problem peculiar to the use of gas for this purpose is one of fuel utilization. Gas is a fuel with a high form value, easy to handle and control. This ease of control makes possible extreme economy, and gas-burning appliances should, therefore, be designed and selected so as to take full advantage of this potential economy.

Determination on the part of gas companies that building heating is a desirable load to have on their lines has led to an increasing number of such corporations granting materially reduced rates for gas used for heating purposes. These communities in which reduced rates for heating purposes have been granted are of a widely diversified character as to size, climate, geographical situation and industries. In natural gas territory, the rates, while showing a tendency to increase, are still such that gas is a cheap fuel for any purpose. The most marked effect of more costly natural gas has been the increasing demand for efficient gas-burning appliances.

The average user of gas for heating is in the very enjoyable situation of having the corporation from which he purchases his fuel display a continued interest in the up-keep and efficient operation of the fuel-burning appliance. A large proportion of the gas-burning heating appliances that are installed are distributed through gas companies. The gas company then stands ready to see that the purchaser of the appliance enjoys uninterrupted and efficient service from it. A notable development of comparatively recent date is the offering of gas-burning boilers designed with the object of meeting the requirements peculiar to large scale heating. Compact and automatic in operation, these large unit boilers are appropriate to the heating requirements of commercial, industrial and institutional buildings.

ORIGINAL INSTALLATIONS COMPARED WITH CONVERSIONS (FOR CENTRAL HEATING PLANTS)

During the period when gas heating was limited to those localities where a cheap supply of natural gas was available, practically all installations were *conversions;* that is, appliances designed for coal, with gas

Material for this Chapter prepared especially for THE GUIDE by the following committee: W. Elliott Stark, *chairman;* K. M. Connor, E. R. Downe, H. B. Johns, N. T. Sellman and A. E. Stacey.

burners inserted in them. This practice has not been generally followed by manufactured gas companies, for definite economic reasons.

The usual coal-burning appliance is designed so as to present a large amount of heating surface to the radiant heat emitted by the flame and fuel bed. Flue passages for the absorption of heat by convection are large because the draft loss, already large on account of the fuel bed resistance, must be kept within reasonable bounds. Heating surfaces in the flue passages must not be so great as to cool the stack gases to a very low temperature, since high stack temperature is required to produce sufficient draft for high rates of combustion.

When gas is burned in appliances, it may be burned either with a Bunsen (non-luminous) flame or with a luminous (radiating) flame. If a Bunsen flame is used and no attempt made to cause this flame to produce radiant heat, such as by the use of refractories; the heating surface in the combustion chamber will absorb heat much slower than it would if a solid fuel were burning in the combustion chamber with an incandescent flame and fuel bed. The next result is that the appliance cannot absorb as much heat as is necessary to produce rating.

By burning the gas with a luminous flame, or in such a manner as to heat refractory surfaces to incandescence, the heat absorbing *in the combustion chamber* of the appliance designed for coal can be made to absorb the heat they were intended to absorb. The large flue passages, however, are not efficient as heat absorbing surfaces because they do not bring the hot gases in sufficiently intimate contact with water-backed surfaces. The use of incandescent refractory surfaces, therefore, increases the heat absorbing capacity of the appliance, but we are still faced with the fact that if sufficient gas is burned to cause the appliance to deliver rated capacity, the stack temperature will be so high as to cause the loss of a great many expensive heat units. If, on the other hand, the rate of gas consumption is adjusted so as to give a low stack temperature and therefore high efficiency, the output of the appliance will be below its capacity when burning solid fuel or liquid fuel.

GAS BOILERS

Gas boilers have taken on a well-defined form just as coal boilers have. The usual boiler is sectional in construction with a number of independent burners placed beneath the sections. In most boilers each section has its own burner. Some designers fashion their sections so as to give the effect of a horizontal tubular boiler in order to accelerate water circulation. Other makers either do not incorporate the tubular feature in their designs or depend on internal baffling to give the tubular effect. In all cases the sections are placed very close together, much closer than would be possible with any soot-forming fuel. The effort of the designer is always to break the hot gas up into thin streams, so that all particles of the heat-carrying gases can come as closely as possible to the heat-absorbing surfaces. Because there is no fuel bed resistance and because the gas company supplies the motive power to draw in the air necessary for combustion (in the form of the initial gas pressure) draft losses through gas boilers are low. A gas boiler will therefore operate with a very slight draft, thus making it possible to run at very low stack temperatures.

INSTALLATION AND CONTROL OF BOILERS AND OTHER APPLIANCES

One feature of the piping installation that adds to the satisfactory service rendered by gas boilers is provision for adequate and rapid venting of the air from steam heating systems. If air leaks into the steam distribution system during the period that the gas is turned off, and then vents out slowly when the thermostat calls for heat, the result will be a further cooling of the premises between the time that the thermostat calls for heat and the time that steam reaches the radiators. A freely venting steam or vapor system gives maximum economy and minimum temperature variation. When gas boilers are attached to existing heating plants, it is good practice to check the effectiveness of the venting devices and if necessary, replace them with more effective ones that will prevent the return of air into the heating system, and also to check the tightness of the piping.

On account of the ease and effectiveness with which the fuel can be controlled, gas-burning appliances are particularly adaptable to full automatic control. Standard equipment on steam boilers quite generally includes provision for control through a thermostat, steam pressure regulation, and safety devices by means of which the gas is cut off either by lowering of the water in the boiler below a safe level, or by extinguishment of the pilot burner. Water boilers are adapted to operation under thermostatic room temperature control and are also provided with water temperature control, as well as the safety pilot feature. Warm-air furnaces can be under the control of thermostats in the spaces being heated, as well as thermostats located in the heat ducts for the purpose of preventing unpleasantly hot air reaching the heated spaces. Variations in the pressure under which the gas is supplied to the appliance are controlled by means of a gas-pressure regulator. This is a standard part of practically all makes of gas-burning heating appliances.

WARM AIR FURNACES

Gas-burning warm-air furnaces are variously constructed of cast iron, sheet metal and combinations of the two materials. If sheet metal is used, it must be of such a character that it will have the maximum resistance to the corrosive effect of the products of combustion. With some varieties of manufactured gases, this effect is quite pronounced and extremely difficult to contend with. Warm-air furnaces are obtainable in sizes from those sufficient to heat the largest residence down to sizes applicable to a single room. The practice of installing a number of separate furnaces to handle individual rooms is peculiar to mild climates, such as southern California. Small furnaces, frequently controlled by electrical valves actuated by push-buttons in the room above, are often installed to heat rooms where heat may be desired for an hour or so each day. The same fundamental principle of design that is followed in the construction of boilers; that is, breaking the hot gas up into fine streams, so that all particles are brought as close as possible to the heating surface, is equally applicable to the design of warm-air furnaces. The remarks in a previous paragraph, relative to the great desirability of using an

appliance designed for gas, when gas is to be the fuel, perhaps apply even more strongly to furnaces than they do to boilers.

Codes for the proportion of warm-air heating plants, such as that formulated by the *National Warm Air Heating Association* (see Chapter VIII), are equally applicable to gas furnaces and coal furnaces. Recirculation should always be practiced with gas-fired warm-air furnaces. It not only aids in heating, but is essential to economy. Where fans are used in connection with warm-air furnaces for residence heating, it is well to have the control of the fan and the gas so coordinated that there will be sufficient delay between the turning on of the gas and the starting of the fan, to prevent blasts of cold air being blown into the heated rooms.

SPACE HEATERS

In residence heating work, the space heater is most commonly used in the form of a radiant heater. Radiant heaters make admirable auxiliary heating appliances to be used during the occasional cool days at the beginning and end of the heating season; when heat is wanted in some particular room for an hour or two. The radiant heater gives off its heat in the form of radiant energy emitted by an incandescent refractory that is heated by a Bunsen flame. Radiant heaters, and all other types of space heaters as well, are preferably flue connected and should never be operated in unvented rooms, particularly bedrooms.

Luminous flame reflector heaters diffuse a large part of their heat by virtue of the radiating power of the bright yellow flame. They are usually backed by a polished copper sheet which reflects radiant heat into the room.

Convection type heaters are typified by the gas-fired steam radiator, the gas-fired tubular heater (built in radiator form) and the floor furnace. The radiator types of gas-fired heaters provide an economical form of heating apparatus for intermittently heated spaces, such as stores, small churches, and some types of offices and apartments. Since they give off the greater portion of their heat by convection they do not produce a *hot spot* within the room and are therefore capable of being operated under thermostatic control. The floor furnace is a convection type heater that is hung underneath the floor. It is generally installed with a duplex register having a warm-air outlet and a cold-air return, so that complete recirculation is secured.

COMBUSTION OF GAS

Most gas appliances consume the gas with a blue or Bunsen flame, although some room heaters use a luminous or yellow flame. Bunsen flames and luminous flames differ in the way in which the air necessary for combustion is supplied. Bunsen type burners are provided with an external mixer, in which a portion of the air is mixed with the gas previous to ignition. This is called primary air. The aspirating effect of the jet of the mixture issuing from the burner ports, and the chimney effect of the gas passages above, draw currents of air past the flame and into it, in sufficient quantity to cause complete combustion. This is known as

secondary air. In order for combustion to be complete and for the products to be free of carbon monoxide, it is necessary that heating surfaces be sufficiently high above the burner to prevent the pale blue inner cone, which is a characteristic part of a Bunsen flame, from striking any cold heating surfaces. A yellow tip on the flame indicates insufficient primary air and is corrected by opening the adjustable air shutters.

Some room heaters which consume gas in very small amounts use the luminous flame. A luminous flame is limited in its application to appliances burning small amounts of gas on account of the increased furnace volume required for combustion. No part of a luminous flame can be allowed to touch any cold surface, as this will result in incomplete combustion with the formation of soot and carbon monoxide.

Table 1 shows the heat values of a cubic foot of three common varieties of gas, together with the theoretical air requirements and the air requirements with 50 per cent excess. In practice excess air must be admitted to the fire in order to insure complete combustion.

TABLE 1. VOLUME OF AIR REQUIRED FOR COMBUSTION OF DIFFERENT GASES

GAS	B.T.U. PER CUBIC FOOT	THEORETICAL AIR PER FOOT OF GAS	ACTUAL AIR WITH 50 PER CENT EXCESS
Natural Gas	1131	10.70 C. F.	16.05 C. F.
Coke Oven Gas	560	4.78 C. F.	7.17 C. F.
Mixed Coke Oven and Water Gas	537	5.03 C. F.	7.55 C. F.

In designing and installing gas-burning installations, particularly where large amounts of gas are to be consumed, it is important that provision be made for the easy access of sufficient air to support combustion and to provide boiler room ventilation. Very little motive force exists to draw air into the boiler room. Therefore, the opening through which it enters must be large enough to keep the velocity to a very low value.

It is well to see that appliances have the *A. G. A.* approval seal and installation should be made in accordance with the recommendations of *A. G. A.* Bulletin on Requirements for House Piping and Appliance Installations.

CHIMNEYS

See Chapter VI and the material relating to gas appliance chimneys contained therein.

HEAT VALUE AND EFFICIENCY

When gas is burned a large amount of water vapor is produced as one of the products of combustion. This ordinarily escapes up the chimney, carrying away with it a certain amount of heat. However, when the heat value of gas is determined in an ordinary calorimeter, this water vapor is condensed and the latent heat of vaporization that is given up during the condensation is reported as a portion of the heat value of the gas. The heat value so determined is termed the "Higher Heat Value" and this is what is ordinarily meant when the heat value of gas is specified.

The heat that is reclaimed by the condensation of the water vapor amounts to about 10 per cent of the total heat value. It is practically impossible to utilize the entire higher heat value of the gas in any house-heating appliance, because to do so it would be necessary to cool the products of combustion down below their dew-point, which is ordinarily in the neighborhood of 130 deg. A stack temperature of 130 deg. is not sufficient to produce a good draft under actual installation conditions.

The heat balance of a gas-burning heating boiler or furnace, therefore, includes the following items:

Heat in the dry flue gas.
Heat in the water vapor.
Heat loss due to incomplete combustion.
Heat loss through radiation.
Heat absorbed by the water or air in the boiler or furnace.

Table 2, shows the maximum theoretical efficiencies when burning a typical manufactured gas with various stack temperatures. These are based on the higher heat value of the gas, and do not include any correction for radiation from the boiler covering. Radiation will reduce these efficiencies as much as 5 per cent, depending on the insulating properties of the covering. The gas is assumed to be burned with 35 per cent excess air and has the following composition:

CO_2	8.6 per cent	
H_2	52.5 " "	
CH_4	31.6 " "	
C_2H_4	1.1 " "	Heat value per cubic foot at 60 deg. fahr.
C_6H_6	1.1 " "	and 30 in. hg., 535 B.t.u.
O_2	0.1 " "	Specific gravity 0.58 (air = 1)
CO_2	1.5 " "	Air Temperature 60 deg. fahr.
N_2	3.5 " "	Atmospheric moisture neglected.
	100.0	

TABLE 2. PRODUCTS OF COMBUSTION AND THEORETICAL EFFICIENCIES WITH A TYPICAL MANUFACTURED GAS

Stack Temperature (deg. fahr.)	250	275	300	350
Heat in Dry Flue Gas above 60 deg. (%)	3.57	4.05	4.52	5.48
Heat in Water Vapor above 60 deg. (%)	9.13	9.22	9.30	9.47
Heat absorbed by boiler, or efficiency (%)	87.30	86.73	86.18	85.05
Radiation (not calculated)	0	0	0	0
	100.00	100.00	100.00	100.00

Flue Gas Analysis

CO_2 11.18% O_2 5.63% N_2 83.19%

It will be seen from Table 2 that the maximum attainable efficiency under practical operating conditions, which include the necessity of having a stack temperature sufficiently high to insure a good draft, and with a normal radiation loss, is approximately 80 per cent.

RATINGS FOR GAS-HEATING APPLIANCES

Since a gas appliance has a heat generating capacity that can be predicted accurately to within 1 or 2 per cent, and since this capacity is not affected by such things as condition of fuel bed and soot accumulation,

makers of these appliances have an opportunity to rate their product in exact terms. Consequently, all makers give their product an hourly B.t.u. rating. This is the amount of heat that is available at the outlet of a boiler in the form of steam or hot water, or at the bonnet of the furnace in the form of warm air. In the case of boilers, this rating can be put into terms of square feet of equivalent direct radiation by dividing it by 240 for steam, and 150 for water. This gives what is called the *A. G. A.* (*American Gas Association*) rating, and is the manner in which all appliances approved by the *American Gas Association* Laboratory are rated. To use these ratings it is only necessary to increase the calculated heat loss or the equivalent direct radiation load by an appropriate amount for starting and piping, and to select the boiler or furnace with the proper rating.

It might be stated at this point that the rating given by the *American Gas Association* Laboratory is not only a safe rating when considered from the standpoint of capacity; but is also a safe rating when considered from the standpoint of physical safety to the owner or care-taker. The rating that is placed upon an appliance is limited by the amount of gas that can be burned without the production of an amount of carbon monoxide that would be dangerous to human life. This same limitation applies to all classes of gas-consuming heating appliances that are tested and approved by the Laboratory. Gas boilers are available with ratings up to 10,000 sq. ft. of steam, while furnaces with ratings up to about 500,000 B.t.u. per hour are available.

HEATING COSTS
(RESIDENCES AND SIMILAR BUILDINGS)

The subject of heating costs will be considered under two divisions. First, the cost of heating the average residence with gas, and second, the cost of heating larger buildings, such as office buildings. A great deal of data are available from which to draw conclusions as to the heating cost for the average residence, but the data pertaining to the cost of heating large buildings are not so extensive.

It is a fact, based upon observation, that the user of a gas-fired central heating appliance in a residence uses more heat during the course of a year than he does when depending upon solid fuel. The extreme ease of starting and operating a gas-burning appliance leads to the pilot light being lighted on the first cool day of the season. Thereafter the system generally operates entirely under thermostatic control. It is in operation on many days when very little heat is required, days when it would be impracticable or inconvenient to keep a coal-fire going. On many cold days the gas unit is kept operating continuously at maximum capacity, so that the premises are never permitted to cool below the temperature ordinarily maintained.

For a given building maintained at a given temperature, the curve of gas consumption follows the curve of outdoor temperature very closely. The efficiency of the appliance is almost independent of the load, so that the gas consumption is almost proportional to the temperature difference. This property of the gas-burning heating plant makes it relatively easy to estimate the heating costs once the basic relations have been determined.

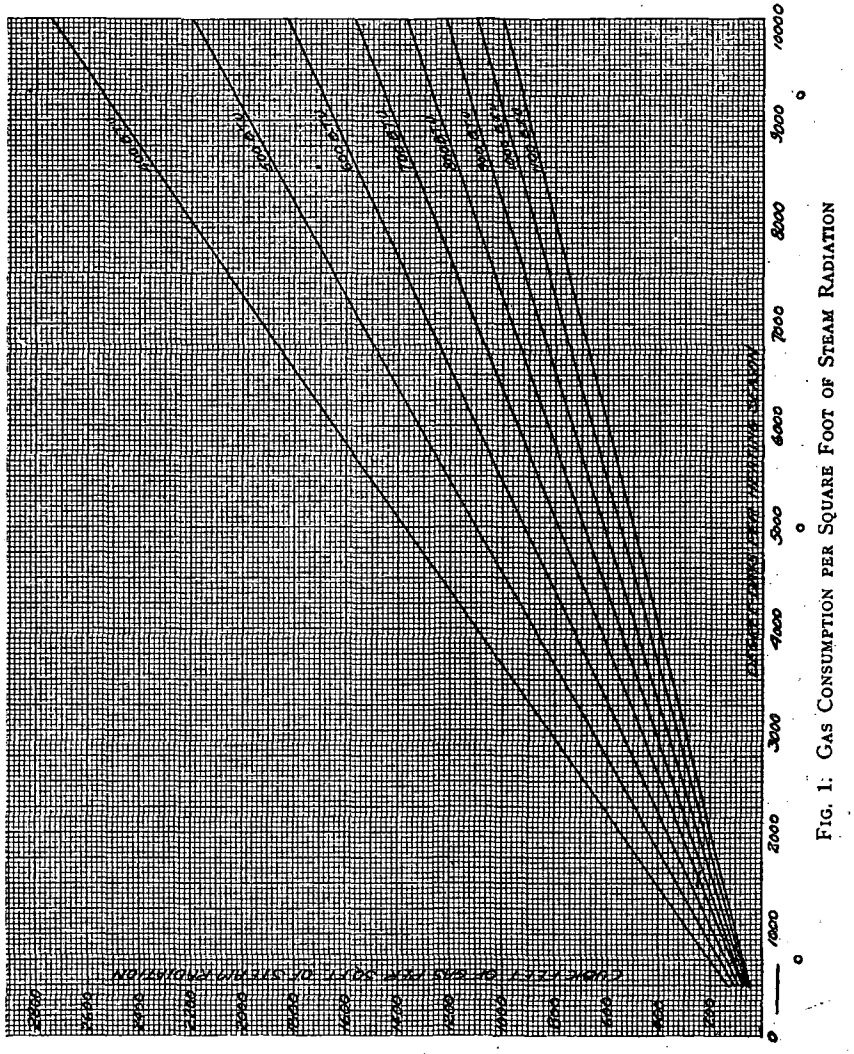


FIG. 1: GAS CONSUMPTION PER SQUARE FOOT OF STEAM RADIATION

In making an estimate of the gas that will be consumed by a gas-fired heating installation during the average heating season, two variables must be taken into account. The first of these is the size of the heating system, usually expressed in terms of square feet of direct cast-iron radiation. The other one is the duration and intensity of the heating season. This is easiest expressed in terms of *degree-days*. A definition of the term *degree-day* may be in order. It has been found that people who use gas under automatic control for heating their homes, seem to require heat on those days when the mean temperature drops below 65 deg. Thus 65 deg. is taken as the datum line from which to measure the number of degree-days in a month or any other given period. The degree-day can be defined as a day on which the mean temperature is one degree below 65 deg., or 64 deg. Therefore, if the mean temperature for each of the 30 days in a month was 64 deg., we would have accumulated 30 deg.-days in that month. By summing up the degree-days for the different days of the heating season, we get the total degree-days for the entire heating season. Studies of weather reports have established the number of degree-days for over 300 cities in the United States and Canada, and it is easy to calculate the heating demands for a particular city. Gas consumption for a given type and size of installation will always be proportional to the number of degree-days in the heating season for the locality in question. A very complete chart, giving the characteristics of the heating season for all parts of the entire Continental United States, was published by the *Heating and Ventilating Magazine* in 1925. Table 3 gives values of degree-days for several representative cities.

By averaging the records of a large number of gas-boiler installations, operating under thermostatic control, with a reduced temperature at night, the following equations have been derived:

$$\text{For Steam } G = \frac{110 \times R \times D}{H} \qquad \text{For Water } G = \frac{64 \times R \times D}{H}$$

where G = cubic feet of gas per season
R = square feet of direct cast-iron radiation (as calculated)
D = degree-days per season
H = B.t.u. (gross) per cubic foot of gas

Example.—To estimate the gas consumption for the average heating season for a 200 sq. ft. steam heating system in Chicago.

From Table 3 it is found that the average heating season in Chicago has 6007 degree-days. The gross heat value of the gas supplied to that city is 535 B.t.u. per cubic foot. Substituting in the equation:

$$G = \frac{110 \times 200 \times 6007}{535} = 247{,}017 \text{ cu. ft.}$$

Observe in the equation that the calculated theoretical amount of radiation is to be used. By this is meant the actual amount of radiation that is required, as determined by accepted methods of heat loss calculations. Over-radiation will not materially affect the gas consumption while under-radiation will merely reflect itself in inability to heat in extremely cold weather. The amount of gas consumed for heating a residence during any given heating season may vary decidedly from an estimate according to the method outlined but the variation will be in almost direct proportion to the difference between the actual degree-

days for the season in question and the average degree-days as shown in Table 3.

TABLE 3. DURATION OF HEATING SEASON

City	Degree—Days for Heating Season
Atlanta	2880
Boston	6055
Buffalo	6750
Cincinnati	5302
Cleveland	6096
Chicago	6007
Dallas	2455
Denver	5880
Detroit	6202
Jacksonville	1080
Kansas City	5302
Minneapolis	7953
New York	5303
Oklahoma City	3827
Pittsburgh	5327
San Francisco	3450
St. Louis	4583
Philadelphia	4950
Seattle	5156
Washington	4562

PROPORTIONING RADIATION

The charts of Figs. 1 and 2 graphically represent the number of cubic feet of gas per square foot of radiation for the heating season in any climate, the climate being expressed in degree-days, and are applicable to any heating condition in the United States. These charts give very close estimates when the radiation is proportioned to maintain a maximum inside temperature of 70 deg. and when that temperature is maintained.

It seems hardly possible to formulate a general rule to cover the estimating of fuel consumption when temperatures other than 70 deg. are to be maintained; at least to formulate a rule based upon the ones just given. For example, the maintenance of a temperature other than 70; let us say 55 deg.; would amount to cutting a much different proportion off the heating season in San Francisco than would be the case in some other locality, for example, New York. It would seem, therefore, that in the absence of sufficient data on which to base rules for estimating fuel consumptions in those cases where temperatures other than 70 are to be maintained with the building to be heated, it would be safest to handle each case individually, strictly according to its own peculiarities. A suggested procedure would be to examine the weather reports for the locality in question, determine the difference between the average outdoor temperature and the temperature to be maintained in the heated spaces for each week during the heating season, and then calculate the actual heat loss for each of the weekly periods taken. The total loss for the heating season; which would of course differ in length from the usual heating season, which is based on the maintenance of an indoor temperature of 70 deg.; divided by an assumed year-around efficiency for the entire heating plant, which could safely be taken as 75 per cent; would

give a very fair estimate of the annual fuel requirement expressed in B.t.u. to be supplied to the gas-burning appliance.

CROSS-CONNECTING COAL AND GAS BOILERS

Quite frequently, when a customer already has a coal boiler in his home, it is sometimes expedient to leave the coal boiler in place, and to cross-connect the gas boiler with it. Where gas heating is new to the community, it produces a more secure feeling in the customer's mind when putting in gas-fired house-heating equipment, if he knows that he can burn coal at any time he has occasion to.

In hot-water heating systems, it is necessary to valve off the return pipes on the coal boiler, which prevents circulation through the latter when the gas boiler is in use. Since the gas boiler holds comparatively little water and is almost always insulated, no valves are needed on the return pipes to the gas boiler. Hence, by opening the valves on the coal boiler, it may be operated independently or in conjunction with the gas boiler.

For steam or vapor installations, it is necessary to valve off all the returns and flows on each boiler unless the gas boiler is set so that the water line in both boilers is at the same level, in which case it is necessary to valve off only the coal boiler to prevent the heating of the water in the coal boiler when it is not in use.

The gas boiler should be set as close to the coal boiler as practicable, and the flows and returns should cut into the flows and returns of the coal boiler as near to the latter as possible.

LARGE BUILDING HEATING COSTS

The foregoing material on the estimating of heating costs when gas is used as the fuel is somewhat more applicable to residences than it is to large buildings or to buildings that are used for other than residential purposes. The use of specially designed gas boilers for large installations, such as office buildings, department stores, and other buildings of a similar nature, is increasing so rapidly that it is possible to give fairly accurate data covering several phases of these installations. In comparing the true cost of heating a large building of a commercial nature with gas, as opposed to other fuels, there are a number of items that should be considered in addition to the bare fuel costs. Rental value of the floor space occupied by the boiler installation and of the space required for fuel and ash storage, may have a strong bearing on the true cost of heating. When gas is burned the added feature of cleanliness resulting from the elimination of coal delivery and ash removal may add materially to the attractiveness of the building. It is difficult to evaluate the reduced necessity for redecoration when gas is used, because the frequent changes in tenancy encountered in this class of building always necessitate redecoration. There are many cases however, where this factor has a tangible value.

The supervision of a gas-heated plant is reduced to a minimum. The methods of control produce a uniform temperature at all times, with the minimum requirement of making sure that the pilots are operating and that the temperature controls are set at the proper joint. It is often

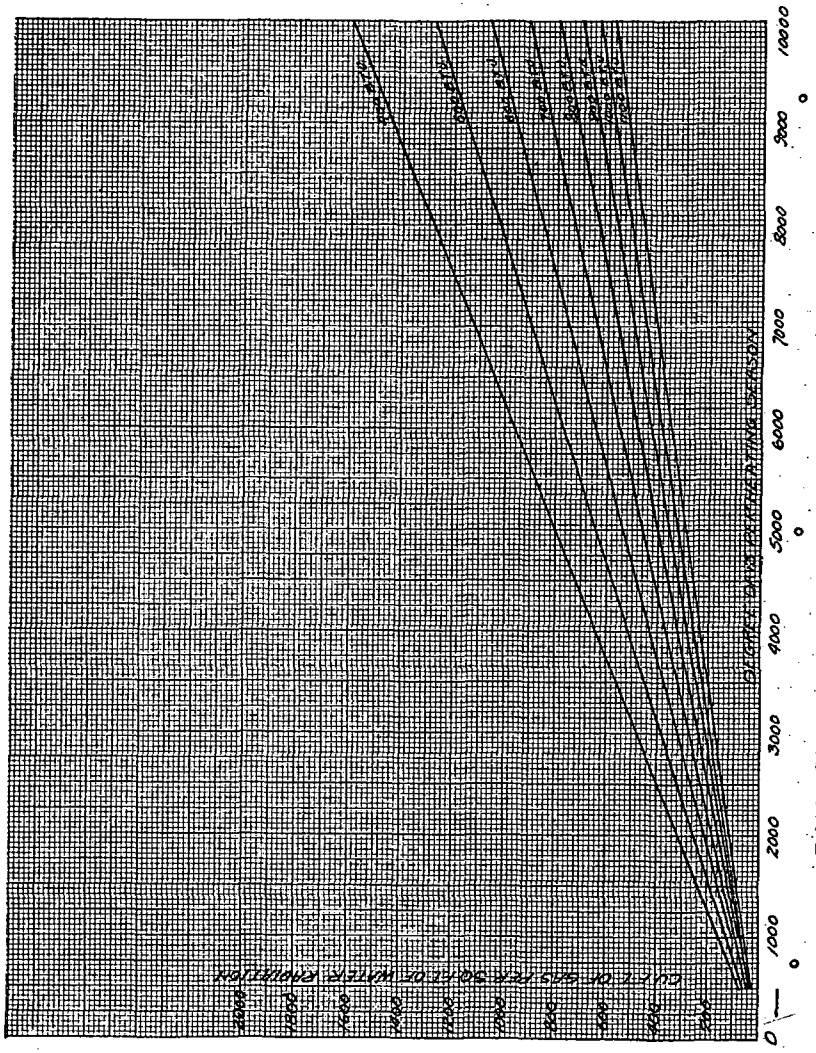


FIG. 2. GAS CONSUMPTION PER SQUARE FOOT OF HOT WATER RADIATION

possible to eliminate on even the smallest job three engineers and coal-passers, substituting therefor about a half-hour's supervision of a building supervisor or porter. Gas companies generally provide necessary engineering attention to the installations, such as periodic inspections; which include cleaning, washing down and adjustment of controls and burners.

Gas-fired installations for larger building heating are controlled by the usual methods, or by the application of distinctive gas methods designed to prevent sudden large demands on the gas services at the instant when the boilers are called upon for heat. Where a battery of boilers are installed, magnetic valves bleeding gas from the tops of unbalanced snap-action diaphragm valves may be employed under the control of an intermittent timing device or of a conventional type of thermostat. By drilling the bleed orifice on each of the boilers of a different size, the boilers will come on at intervals, depending on the size of the bleed orifice. In this way the full demand is not allowed to come on the meters or gas service instantaneously and full line pressure is available for each of the boilers as it starts. In the same way, when the boilers are shut down, the demand is taken off in steps, eliminating fluctuations in the service pressure.

The steam pressure controls on each one of a battery of several boilers may be set to cut off at different steam pressures. By this means, one boiler can be allowed to carry the base load and the other boilers can be allowed to come on at different pressure intervals, and thus carry the peak-loads.

GAS REQUIREMENTS FOR LARGE BUILDINGS

It has been found by analysis of a number of installations that the values given in Table 4 represent the gas requirements of large commercial building heating installations under thermostatic control, expressed in B.t.u.'s per square foot of steam radiation per degree-day.

TABLE 4. GAS REQUIREMENTS FOR LARGE BUILDINGS

Steam Radiation	B.t.u. per Square Foot, per Degree—Day
1000	114.5
2000	110.0
3000	107.0
4000	105.0
5000	104.0
6000	102.0
7000	100.5
8000	99.0
9000	97.5
10000	96.0
11000	94.5
12000	92.7
13000	91.0
14000	89.5
15000	88.0
20000	80.5

These values can be converted into annual gas consumptions by the method outlined on a preceding page.

The rate structures of many gas companies are so devised that additional uses of gas, such as hot-water supply, restaurant use and incineration are charged for at preferential rates if the main load is for building heating.

CHAPTER XV

HEAT INSULATION FOR PIPES AND SURFACES

Uninsulated Surfaces, Cold Surfaces, Hot Water and Steam Lines, Effective Air Velocity, Economic Thickness.

IN order to be able to estimate the savings that can be effected by insulating a hot-water or steam line with a specified covering, it is first necessary to know accurately the heat loss from the bare line.

HEAT LOSS FROM UNINSULATED SURFACES

Fig. 1 shows the loss in B.t.u. per square foot of bare pipe surface per hour per degree Fahrenheit temperature difference for various diameter pipes.

Table 1 gives the B.t.u. loss as well as the loss in dollars and cents and in pounds of coal per 100 lineal feet of bare pipe for temperatures up to 350 deg. fahr. Pounds of coal used are given per 100 lineal feet of pipe per month (assuming continuous use of the apparatus, 70 per cent boiler efficiency, and 13,000 B.t.u. per pound of coal). The *dollars* column represents the money value of the coal used per 100 lineal feet per month (assuming coal at $4.00 per ton and boiler room expense at $1.00 per ton).

The heat loss from bare pipes of various diameters up to 18 in. and at various temperatures can be calculated from the empirical equation

$$Q = 3320 \frac{77 + Td - 103\, D^{0.11}}{103\, D^{0.11} - Td + 1020}$$

where

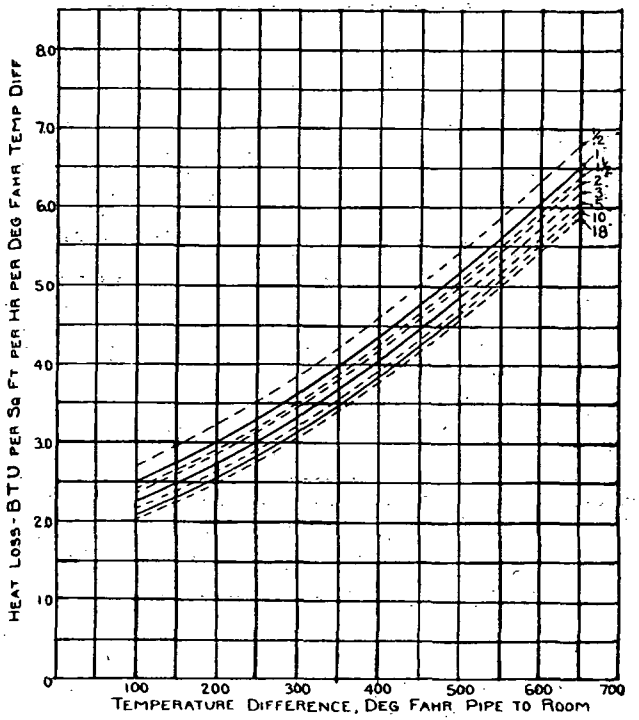
Q = B.t.u. loss per hour per square foot of bare pipe surface.
D = outer diameter of pipe, in inches.
Td = temperature difference between pipe surface and air, deg. fahr.

The loss of heat per unit area from flat surfaces varies greatly with the size and position of the body. The loss from the surface in a horizontal position is entirely different for the same surface in a vertical position. Also, the loss is different for the same flat surface facing downward or upward. For these reasons a single equation or curve has not yet been obtained that will give accurately the heat loss from flat surfaces in various positions. However, until more experimental work has been conducted, it is suggested that the heat loss from flat bare iron surfaces

Material for this Chapter prepared especially for THE GUIDE by the following committee: R. H. Heilman, *chairman;* E. C. Lloyd, G. B. Nichols and L. B. McMillan.

be taken as equal to 95 per cent of the values given for the 18-in. pipe in Fig. 1.

In order to determine heat losses per linear foot of pipe from known losses per square foot, it is necessary to know the number of square feet area per linear foot of pipe. Table 2 gives these areas for various standard pipe sizes while Table 3 gives the area in square feet for flanges and fittings for various standard pipe sizes.



(R. H. Heilman, *Mech. Eng.*, Vol. 46 [1924], p. 593)

FIG. 1. BARE PIPE LOSS CURVES

INSULATION FOR COLD SURFACES

The data appearing in this section are taken mostly from the paper by L. L. Barrett[1] which was presented before the AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS in 1923.

It is the common practice to insulate cold surfaces for the purpose of preventing sweating even when the question of the heat gained by such surfaces is of no economic importance. Moisture will be deposited on a

[1]Insulation of Cold Surfaces to Prevent Sweating by L. L. Barrett, TRANSACTIONS A. S. H. & V. E., Vol. 29, 1923.

TABLE 1. LOSSES FROM HORIZONTAL BARE IRON STEAM PIPES

From 100 lineal feet of pipe per month of 30 days with steam in pipes 24 hours per day. Coal at $4.00 per ton of 2000 lb.

Pipe Size	GAGE PRESSURE TEMPERATURES																							
	HOT WATER																							
	120 DEG. FAHR.			150 DEG. FAHR.			180 DEG. FAHR.			210 DEG. FAHR.			239.4 DEG. FAHR.			324 DEG. FAHR.			350 DEG. FAHR.					
	Dollars Loss	Lbs. Coal	B.t.u. per Lineal Ft. per Deg. Fahr. Diff. per Hr.	Dollars Loss	Lbs. Coal	B.t.u. per Lineal Ft. per Deg. Fahr. Diff. per Hr.	Dolls. Loss	Lbs. Coal	B.t.u. per Lineal Ft. per Deg. Fahr. Diff. per Hr.	Dolls. Loss	Lbs. Coal	B.t.u. per Lineal Ft. per Deg. Fahr. Diff. per Hr.	Dolls. Loss	Lbs. Coal	B.t.u. per Lineal Ft. per Deg. Fahr. Diff. per Hr.	Dolls. Loss	Lbs. Coal	B.t.u. per Lineal Ft. per Deg. Fahr. Diff. per Hr.	Dolls. Loss	Lbs. Coal	B.t.u. per Lineal Ft. per Deg. Fahr. Diff. per Hr.		
½"	0.53	215	0.543	0.90	363	0.573	1.32	526	0.605	1.77	707	0.638	2.24	897	0.670	3.92	1566	0.779	4.51	1805	0.815			
¾"	0.65	261	0.660	1.09	437	0.690	1.58	635	0.729	2.11	845	0.762	2.70	1083	0.809	4.74	1895	0.943	5.48	2190	0.990			
1"	0.78	313	0.791	1.31	525	0.829	1.91	763	0.878	2.55	1020	0.920	3.26	1305	0.973	5.72	2290	1.14	6.25	2601	1.18			
1¼"	0.97	388	0.979	1.61	646	1.02	2.36	947	1.087	3.19	1275	1.15	4.00	1610	1.20	7.14	2860	1.42	8.18	3280	1.48			
1½"	1.08	432	1.09	1.82	728	1.15	2.65	1060	1.220	3.57	1430	1.29	4.54	1818	1.35	7.98	3190	1.58	9.28	3710	1.67			
2"	1.32	530	1.34	2.21	886	1.40	3.24	1297	1.491	4.37	1750	1.58	5.36	2142	1.60	9.78	3910	1.94	11.37	4549	2.05			
2½"	1.56	625	1.58	2.64	1056	1.67	3.86	1545	1.778	5.18	2075	1.87	6.65	2660	1.98	11.66	4660	2.32	13.66	5460	2.46			
3"	1.86	744	1.88	3.15	1260	1.99	4.56	1824	2.100	6.12	2460	2.22	8.24	3292	2.46	13.88	5550	2.76	16.14	6450	2.91			
3½"	2.11	843	2.13	3.54	1418	2.24	5.18	2070	2.380	6.95	2780	2.51	8.89	3554	2.65	15.82	6325	3.14	18.31	7322	3.30			
4"	2.33	934	2.36	3.95	1580	2.50	5.78	2305	2.650	7.70	3080	2.78	9.87	3950	2.95	17.70	7075	3.52	25.50	8200	3.70			
4½"	2.57	1030	2.60	4.35	1740	2.75	6.35	2540	2.920	8.53	3420	3.08	10.94	4370	3.26	19.48	7790	3.87	22.60	9025	4.07			
5"	2.84	1135	2.87	4.77	1910	3.02	6.95	2780	3.200	9.36	3750	3.38	11.97	4790	3.57	21.25	8500	4.23	24.62	9850	4.45			
6"	3.35	1342	3.39	5.62	2250	3.56	8.20	3280	3.775	11.10	4450	4.01	14.21	5680	4.24	25.30	10,110	5.02	29.30	11,720	5.29			
7"	3.83	1533	3.87	6.40	2570	4.06	9.40	3760	4.325	12.70	5080	4.58	16.18	6470	4.82	29.10	11,640	5.78	33.70	13,480	6.09			
8"	4.27	1710	4.32	7.20	2880	4.55	11.00	4398	5.050	14.24	5700	5.14	18.25	7300	5.45	32.60	13,030	6.45	37.65	15,050	6.84			
9"	4.75	1900	4.80	8.00	3200	5.05	11.62	4650	5.350	15.80	6330	5.71	20.35	8130	6.07	36.25	14,500	7.21	42.10	16,840	7.60			
10"	5.26	2100	5.32	8.86	3550	5.61	12.68	5065	5.925	17.55	7030	6.34	22.05	8820	6.58	40.20	16,100	8.01	46.70	18,690	8.44			
12"	6.18	2475	6.25	10.46	4190	6.62	15.00	6000	6.995	20.65	8270	7.46	26.44	10,580	7.89	47.40	18,950	9.42	55.40	22,120	10.00			
14"	6.74	2700	6.82	11.40	4570	7.22	16.60	6635	7.625	22.40	8980	8.10	28.90	11,560	8.62	51.00	20,800	10.34	60.30	24,200	10.92			
16"	7.66	3065	7.74	12.95	5190	8.20	18.82	7525	8.650	25.50	10,200	9.20	32.80	13,120	9.79	58.76	23,500	11.70	68.40	27,320	12.34			
18"	8.58	3440	8.68	14.53	5820	9.20	21.00	8400	9.650	28.60	11,450	10.33	36.10	14,460	10.80	65.40	26,150	13.00	76.50	30,570	13.80			

In these tables coal has been figured at $4.00 per ton of 2000 lb.—13,000 B t.u. per lb. of coal—labor, boiler room expense, etc., taken at $1.00 per ton, making total value of coal fired at $5.00 per ton. Boiler efficiency taken at 70 per cent. Air temperature 70 deg. fahr. Experimental data obtained at the *Mellon Institute.*

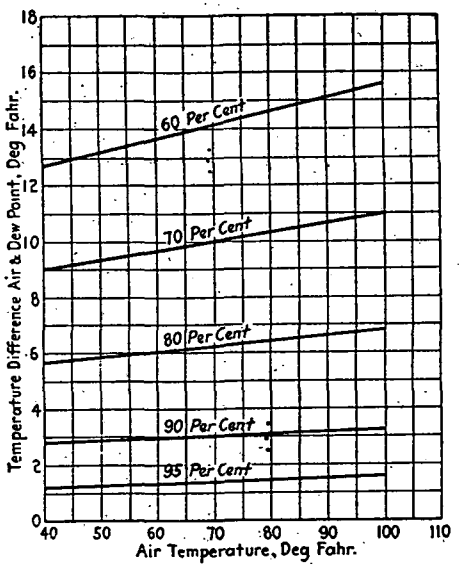


FIG. 2. TEMPERATURE DIFFERENCE BETWEEN AIR AND DEW POINTS AT DIFFERENT RELATIVE HUMIDITIES

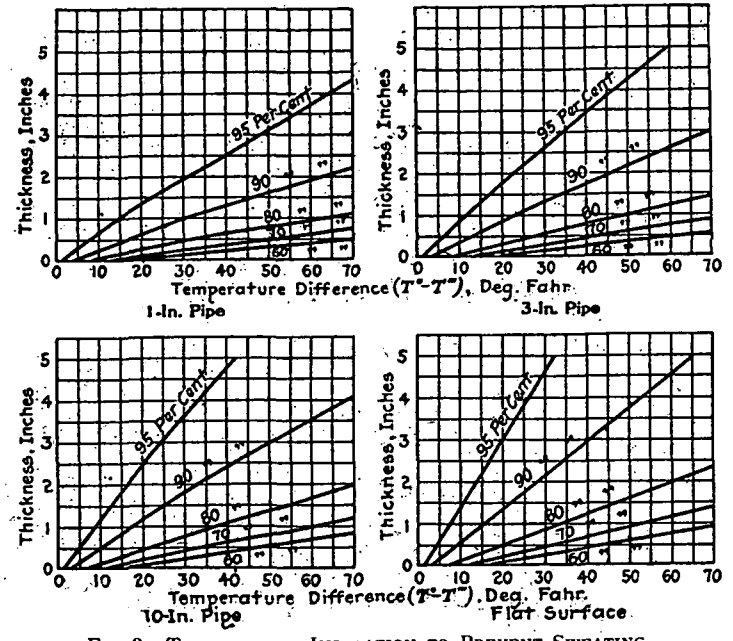
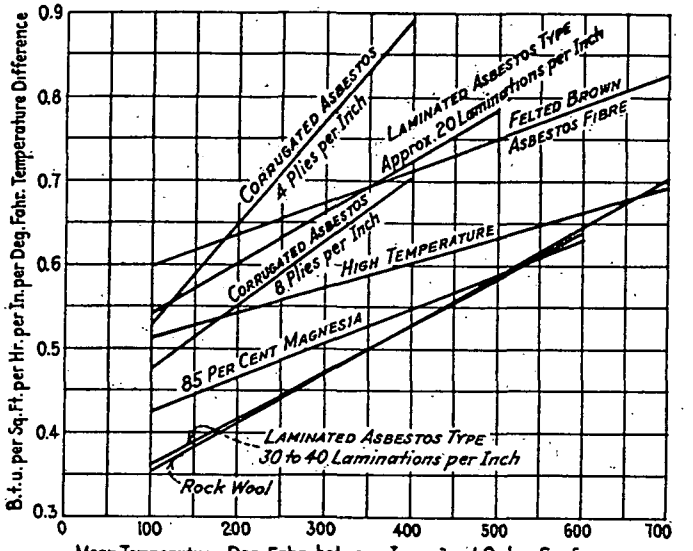


FIG. 3. THICKNESS OF INSULATION TO PREVENT SWEATING

surface whenever its temperature falls to that of the dew point of the surrounding air. Fig. 2 gives the temperature difference between the air and the dew point corresponding to different air temperatures and different relative humidities, as computed from Goodenough's tables.

The temperature of the outer surface of the insulation depends upon the temperature of the air, temperature of brine, thickness of insulation, conductivity of insulation, diameter of insulation surface, nature of



(R. H. Heilman, *Mech. Eng.*, Vol. 46 [1924], p. 593)

FIG. 4. THERMAL CONDUCTIVITY

surface, etc. The conductivity of various coverings in common use are shown in Table 4. A value of 0.3 for k has been used in the computation of the curves shown in Fig. 3. The surface resistance used in calculating these tables has been taken from results obtained on canvas covered surfaces. However, it has been found that the resistance for asphaltic and roofing surfaces is practically the same as for canvas surfaces so that the curves given may be safely used with no alternations for the surfaces commonly used.

To determine the thickness of covering necessary to prevent sweating for coverings having conductivity values differing from the value of 0.3 used in computing the curves increase or decrease the values taken from the curves by the percentages indicated in the last column of Table 4. These percentages will give values approximately correct. In Fig. 3,

T_o = temperature of air on warm side of insulation.
T''' = temperature of the medium on cold side of insulation.

Table 2. Radiating Surface per Linear Foot of Pipe

Pipe Size In.	Surface Sq. Ft.	Pipe Size In.	Surface Sq. Ft.	Pipe Size In.	Surface Sq. Ft.
½	0.22	2	0.622	5	1.456
¾	0.275	2½	0.753	6	1.734
1	0.344	3	0.917	8	2.257
1¼	0.435	3½	1.047	10	2.817
1½	0.498	4	1.178	12	3.338

INSULATION OF HOT WATER, LOW AND HIGH PRESSURE STEAM LINES

The conductivities, in B.t.u. per square foot per hour per inch thick per degree Fahrenheit temperature difference between inner and outer surfaces of the insulation are given in Fig. 4 for various insulations. In this figure the conductivities are plotted as functions of the mean temperatures or the mean of the inner and outer surface temperatures of the insulations.

This method of plotting conductivities, enables one to readily calculate the heat loss through single or compound sections. It should be emphasized that in this figure, the conductivities given for the various insulations are the average values from a number of tests on each type of material, also that all variables due to differences in thickness, different pipe sizes, and different air conditions are eliminated.

The heat losses through any of the insulations shown in Fig. 4 for various thicknesses of covering and for any temperatures generally used

Table 3. Areas of Flanged Fittings, Square Feet

Nominal Pipe Size I. D.	Flanged Coupling		90 Deg. Ell		Long Radius Ell		Tee		Cross	
	Standard	Extra Heavy	Standard	Extra Heavy	Standard	Extra Heavy	Standard	Extra Heavy	Standard	Extra Heavy
1″	0.320	0.438	0.795	1.015	0.892	1.083	1.235	1.575	1.622	2.07
1¼″	0.383	0.510	0.957	1.098	1.084	1.340	1.481	1.925	1.943	2.53
1½″	0.477	0.727	1.174	1.332	1.337	1.874	1.815	2.68	2.38	3.54
2″	0.672	0.848	1.65	2.01	1.84	2.16	2.54	3.09	3.32	4.06
2½″	0.841	1.107	2.09	2.57	2.32	2.76	3.21	4.05	4.19	5.17
3″	0.945	1.484	2.38	3.49	2.68	3.74	3.66	5.33	4.77	6.95
3½″	1.122	1.644	2.98	3.96	3.28	4.28	4.48	6.04	5.83	7.89
4″	1.344	1.914	3.53	4.64	3.96	4.99	5.41	7.07	7.03	9.24
4½″	1.474	2.04	3.95	5.02	4.43	5.46	6.07	7.72	7.87	10.07
5″	1.622	2.18	4.44	5.47	5.00	6.02	6.81	8.52	8.82	10.97
6″	1.82	2.78	5.13	6.99	5.99	7.76	7.84	10.64	10.08	13.75
7″	2.17	3.46	6.17	8.62	7.38	9.73	9.37	12.33	12.00	16.83
8″	2.41	3.77	6.98	9.76	8.56	11.09	10.55	14.74	13.44	18.97
9″	3.00	4.44	8.71	11.44	10.57	13.17	13.18	17.23	16.78	22.10
10″	3.43	5.20	10.18	13.58	12.35	15.60	15.41	20.41	19.58	26.26
12″	4.41	6.71	13.08	17.73	16.35	18.76	19.67	26.65	24.87	34.11
14″ O. D.	5.39	8.30	16.38	22.31	20.17	25.70	24.81	33.63	31.48	43.15
15″ O. D.	6.18	9.52	18.50	25.28	22.92	29.34	27.91	38.04	35.48	48.79
16″ O. D.	6.69	10.05	20.17	27.18	25.41	31.73	30.32	40.94	38.34	52.35

in engineering practice can be obtained from Table 5 and Figs. 5 to 7 inclusive.

In these curves the unit loss through 1, 1½ and 2-in. thick covering is given for temperature differences up to 700 deg. fahr. The loss through other thicknesses of covering can be obtained from the curves by interpolation.

Table 5 gives the factor by which the loss from the curves shown in Figs. 5 to 7 must be multiplied to give the loss through any of the coverings whose conductivity values are given in Fig. 4.

Table 4. Values of k Corresponding to Commonly Used Coverings

	k	Per Cent Variation from k = 0.3
Hair Felt	0.246	−18%
Keystone Hair	0.27	−10%
Wood Felt	0.36	+20%
Cork, 6.9 lb. per cu. ft.	0.27	−10%
Cork, 9.7 lb. per cu. ft.	0.30	0%
Cork, 16 lb. per cu. ft.	0.35	+17%

Table 5. Pipe-Covering Factors

Type of Covering	Temperature Difference, Pipe to Air, Deg. Fahr.						
	100	200	300	400	500	600	700
85% Magnesia	1.234	1.184	1.148	1.111	1.082	1.051	1.025
Laminated Asbestos Type. Approx. 20 laminations per inch	1.515	1.474	1.441	1.409	1.383	1.360	1.345
Laminated Asbestos Type. Approx. 30 to 40 laminations per inch	1.022	1.019	1.016	1.013	1.010	1.007	1.005
High Temperature	1.438	1.358	1.292	1.233	1.190	1.147	1.109
Felted Brown Asbestos Fibre	1.665	1.577	1.505	1.436	1.387	1.340	1.300
Rock Wool	1.058	1.045	1.035	1.022	1.020	1.014	1.010
Corrugated Asbestos, 8 plies per inch	1.349	1.340	1.333	1.323	.....	.....	.....
Corrugated Asbestos, 4 plies per inch	1.520	1.550	1.580	1.605	.....	.....	.....

Table 6. Thicknesses of Insulation Ordinarily Used

Steam Pressures (Lb. Gage)	Steam Temperatures (Deg. Fahr.)	Thickness of Insulation		
		Pipe larger than 4 in.	Pipes 2 in. to 4 in.	Pipes ½ in to 1½ in.
0 to 25	212 to 267	1 in.	1 in.	1 in.
25 to 100	267 to 338	1½ in.	1 in.	1 in.
100 to 200	338 to 388	2 in.	1½ in.	1 in.
Higher Pressure or Superheat	388 to 500	2½ in.	2 in.	1½ in.
Higher Pressure or Superheat	500 to 600	3 in.	2½ in.	2 in.

Example.—Determine the heat flow in B.t.u per hour per square foot of pipe surface through a magnesia covering 1 in. thick on a 4-in. pipe.

Solution.—The temperature of the pipe is 270 deg. fahr. and the room temperature, 70 deg. fahr. The loss through a covering 1 in. thick on a 4-in. pipe at 200 deg. temperature difference from Fig. 5 = 0.395; the factor for magnesia at 200 deg. temperature difference from Table 5 = 1.184; then the heat loss through the magnesia covering = 0.395 × 1.184 × 200 = 93.5 B.t.u. per square foot of pipe surface per hour.

EFFECT OF AIR VELOCITY ON SURFACE LOSSES

The rate of heat loss from a surface maintained at constant temperature is greatly increased by air circulation over the surface. Fig. 8 is based on Langmuir's equations (*Trans. Am. Electro-Chem. Soc.*, Vol. 23). Other investigators have shown even greater increases in rates of heat loss from bare surfaces due to air velocity.

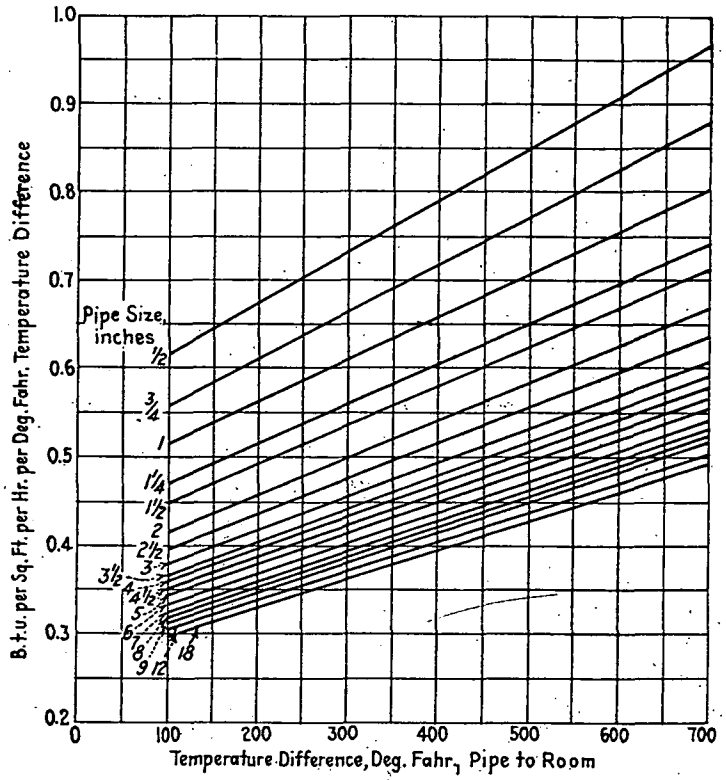


Fig. 5. Heat Loss through 1 in. thick Covering

In the case of well-insulated surfaces the increases in losses due to air velocity are very small as compared with increases shown above for bare surfaces, because of the fact that air flowing over the surface of the insulation can increase only the rate of heat transfer from surface to air, and cannot change the internal resistance to heat flow inherent in the insulation itself. The maximum increase in loss due to air velocity ranges from about 30 per cent in the case of 1 in. thick insulation, to about 10 per cent in the case of 3 in. thick insulation, provided that the insulation is thoroughly sealed so that air can flow only over the surface.

If the conditions are such that the air may circulate through cracks and crevices in the insulation, the increases may be far greater than those given above. Therefore, it is essential that insulation be sealed as tightly as possible. Pipe insulation out-of-doors should be provided with a weather-proof jacket, and other outdoor insulation should be thoroughly weather-proofed.

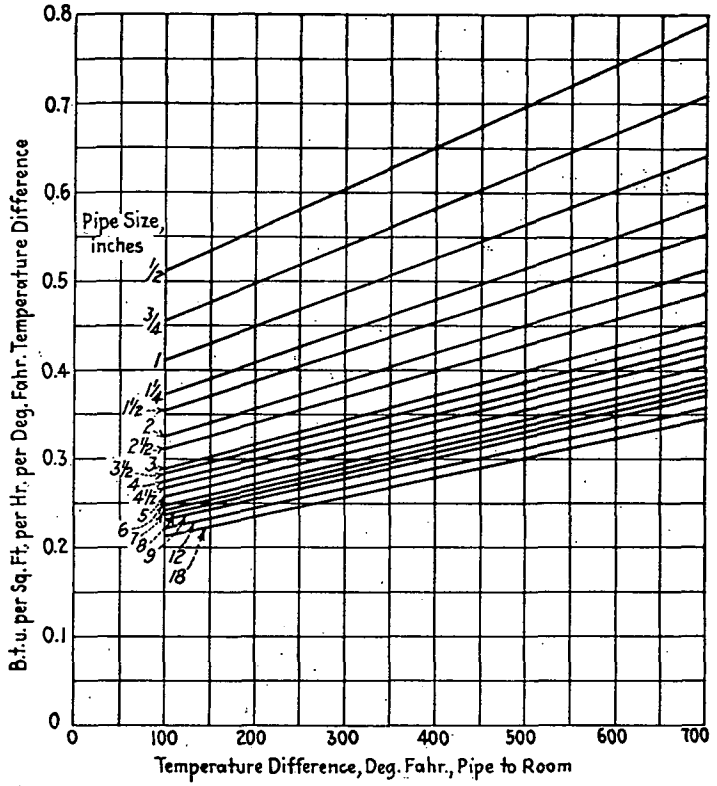


Fig. 6. Heat Loss through 1½ in. thick Covering

ECONOMIC THICKNESS OF INSULATION

Table 6 shows the thickness of insulation which are ordinarily used for various temperature conditions. Where a thorough analysis of economic thickness is desired, this may be accomplished through the use of the chart, Fig. 9.

The dotted line on the chart illustrates its use in solving a typical example. In order to use the chart, start at the lower left hand corner and proceed to the right to a point representing the given number of hours of operation per year; then proceed vertically to the line representing the given value of heat; thence horizontally, to the right, to the line repre-

senting the given temperature difference: thence vertically to the line representing the conductivity of the given material; thence horizontally,

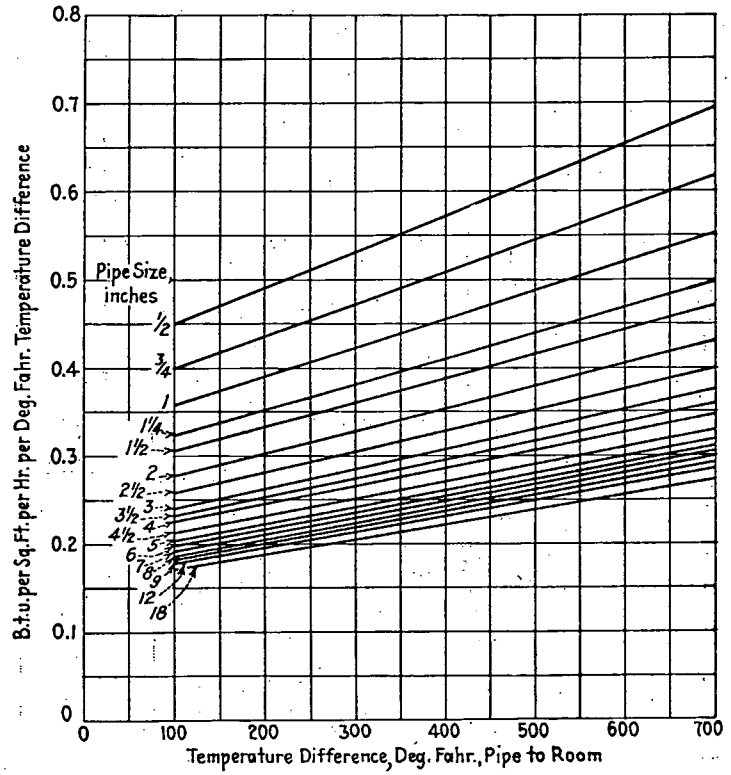


Fig. 7. Heat Loss through 2 in. thick Covering

to the left, to the line representing the given discount on that material; thence vertically to the curve representing the required per cent return on the investment; thence horizontally, to the left, to the curve representing the given pipe size; thence vertically to the scale at the top of the sheet where the economical thickness may be read off directly. The dotted line on the chart illustrates its use in solving a typical example.

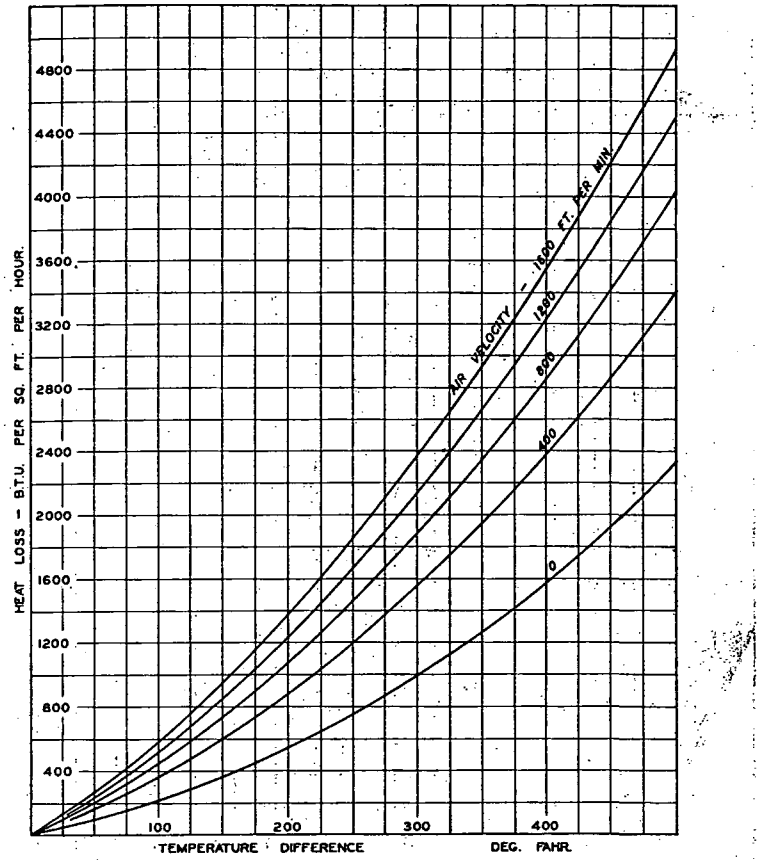
It is impossible to determine accurately the economic thickness of insulation to use for an underground installation owing to the many variables which are present such as depth of line, conductivity of ground, moisture conditions, etc. However, it is considered good practice to insulate underground lines with approximately ½ in. less thickness of insulation than for above ground installations under similar operating conditions.

It is necessary to keep the insulation absolutely dry if the efficiency is to be maintained, therefore, precautions should be taken to thoroughly

weather-proof the insulation and to provide a drainage system for the water which may get into the conduit.

HEAT LOSSES FROM BARE FITTINGS

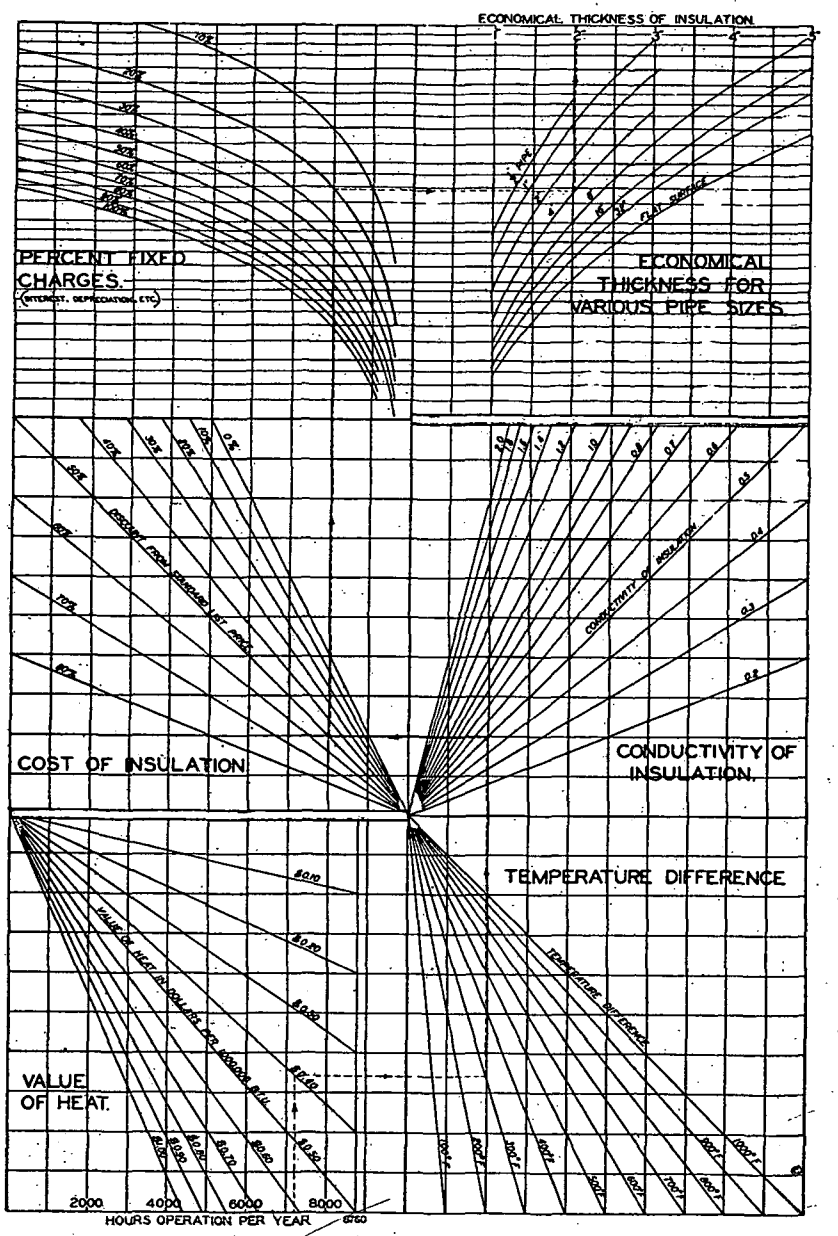
Very often, even where pipes are thoroughly insulated, flanges and fittings are left bare due to the belief that the losses from these parts are



(L. B. McMillan, *Iron and Steel Engineer, July 1925.*)

Fig. 8. Heat Losses from Surfaces Exposed to Various Air Velocities

not large. However, the fact that a pair of 10-in. standard flanges having an area of 3.43 sq. ft. would lose, at 100 lb. steam pressure, an amount of heat equivalent to more than a ton of coal per year shows the necessity for insulating such surfaces. Table 3 shows the areas of both standard and extra heavy flanged fittings including the accompanying flanges bolted to the fittings.



(L. B. McMillan, *Proc. National Dist. Heating Ass'n.*, Vol. 18, p. 131.)

FIG. 9. CHART FOR DETERMINING ECONOMICAL THICKNESS OF INSULATION

CHAPTER XVI

AUTOMATIC HEAT CONTROL

Types of Thermostats, Applications of Automatic Control Air Washers, Unit Heaters, House Heating Systems, Domestic Hot Water, Gas Burning Appliances, Industrial Applications, Double Control, Test Data on Temperature Regulators.

IN the best functioning of many social and commercial services, automatic temperature regulation is proved to be necessary, not only to comfort and health, but also to the prevention of waste and to the perfection of manufacturing processes.

Temperature control is usually achieved by preventing overheating. It follows that *automatic heat control* is a better term than automatic temperature regulation, and it is obvious that automatic heat control in itself must always effect economy.

Overheating is much more common than underheating, and the results of overheating are more harmful to health and efficiency.

All heating equipment must be sufficient in capacity to render acceptable service under the most arduous conditions. The most arduous conditions, especially as to extreme cold outside, are in effect only a small part of the heating season. It may surprise many people to realize that in Chicago, for instance, the most extreme cold prevails only on about six days per year.

During the balance of the heating season the heating apparatus must be operated at much less than full capacity—generally in colder climates at about 40 per cent of the maximum.

Hence there is ample ability and strong probability for overheating during the major part of each heating season unless automatic control of the heating apparatus is provided.

Ventilating systems without automatic heat control give trouble both from excessive overheating and from drafts.

Rooms heated by radiators can be cooled more quickly by opening windows than by shutting radiator valves, so that it is found that great heat waste occurs through open windows and open radiator valves, unless automatic heat control is furnished.

Gas and oil heaters and similar devices using quickly responsive fuels become prohibitively expensive for fuel unless automatic heat control is used.

Service hot-water heaters must have automatic heat control, not only for economy and satisfaction, but also to prevent scalding the bodies of users.

Automatic heat control is responsible for a goodly share in the increase in efficiency of modern manufacturing processes, especially in saving of

Material for this Chapter prepared especially for THE GUIDE by the following committee: J. C. Hornung, *chairman*; G. L. Blanding, S. R. Lewis, F. W. Powers and C. P. Yaglou.

time. It has made possible the drying of lumber in months, where it formerly took years.

In the manufacture of prepared foods automatic heat control has shortened the time and has made the processes exact, saving much spoilage formerly wasted.

The introduction of automatic heat control in manufacturing plants almost always releases labor which would otherwise be kept occupied manipulating valves and dampers.

The installation of automatic heat control is a justifiable investment for many heating systems, inasmuch as it very positively contributes to: (1) conservation of fuel, (2) improvement in health, (3) increase in comfort and efficiency.

Automatic heat control is a desirable addition to or rather a fundamental part of the heating and ventilating apparatus in:

1. All public buildings such as schools, theatres, etc.
2. All residences, particularly those using oil or gas fuel.
3. All offices, especially those having many employees.

Automatic heat control is vitally necessary in order to operate satisfactorily and economically:

1. All manufacturing processes in which heat is employed, and where varying temperatures affect the quality of the manufactured product.
2. All refrigerating systems, especially the ultramodern small automatic unit type.
3. All service hot-water heating systems.

Thermostats

Thermostats are very simple mechanisms. Almost every physical thing expands or changes under the influence of heat and so can be made into a more or less effective thermostat. Liquids can be compounded which will become gases at any reasonable temperature desired. Metals having different rates of expansion can be harnessed together so as to give a greatly increased thermostatic movement. Common air is an excellent thermostatic medium, and is used extensively.

There are two general divisions into which devices for automatic heat control may be grouped, as follows:

1. The simpler class includes the type in which the thermostats and the valves and dampers which they operate are self-contained without any outside power, gaining sufficient energy from the thermostat itself (Fig. 1). This class of apparatus is especially adapted to single installations, as for service hot-water heaters, residence heating, and the like. It is suggested that this kind of thermostat be called the unit type. In present commercial practice most unit type thermostats use the expansive power of a liquid or gas, contained in a hermetically sealed receptacle.

2. The other and more elaborate class of thermostat, Fig. 2, includes the type of thermostat which controls air or liquid or electricity already under pressure, and which by controlling this outside power, operates the dampers or valves against springs or weights and similar opposition which will reverse conditions when the outside power is shut off. There is practically no limit to the power which can be applied in this manner.

It is suggested that this kind of thermostat be called the pilot type. In present commercial practice, pilot type thermostats are used for large buildings, where many thermostats are required, usually with air at about 15 lb. pressure, from an electric or steam compressor.

Compressed air is a very reliable agent, capable of great flexibility and elaboration of control, and is of considerable corollary use for remote operation manually of distant dampers and valves. Pilot type thermostats often are used to operate electric switches, the current then passing to electric motors or to magnets which move the dampers and valves. Electricity is so flexible and adaptable that very complicated and elaborate interlocked functions are possible.

Pilot type thermostats are also used to operate valves on pipes from water supply mains, thus using hydraulic power for moving valves and dampers. Owing to silting up of pipes which have sluggish currents and to corrosion, this method is not always to be advised.

APPLICATIONS OF AUTOMATIC CONTROL

New uses and styles are developed almost daily. Some of the applications will be listed which are believed to be approved methods of installation.

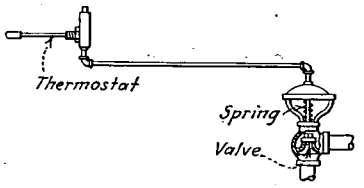


FIG. 1. EXAMPLE OF UNIT TYPE THERMOSTAT

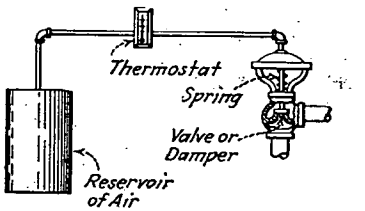


FIG. 2. EXAMPLE OF THERMOSTAT USING OUTSIDE POWER

Note.—The expansive material in the thermostat acts directly on the diaphragm of the valve, against the spring, which opens the valve when the thermostat contracts.

Tempering Heaters

The tempering heaters, particularly if they are of copper with extended surfaces, and if there is a two-pipe vacuum system of steam circulation having a vacuum pump, should be arranged with a separate outer layer of radiation capable of heating the air from the coldest temperature likely to be encountered to a temperature above freezing. This outer layer should be controlled by a thermostat on the cold side set to shut off steam when the outside temperature gets warmer than around 34 deg., and set to keep steam turned on when the outside temperature becomes cooler than 34 deg. There should be an additional layer of tempering heater, controlled by an additional thermostat in the duct beyond the fan discharge after mixing of the strata of air shall have been accomplished by the fan. This thermostat should be set to control the temperature at the desired degree for cooling the building, such as will give an average temperature at the delivery opening of say 65 deg., or if this causes drafts, at a slightly higher temperature.

If there is no vacuum system of steam circulation, it is decidedly likely that any attempt to control the temperature by opening and closing steam and return valves will result unfavorably, due to freezing of the radiation and sudden temperature fluctuations in the rooms, as tempering heaters are immediately responsive and flash hot or freeze solid with great rapidity. Where no vacuum system is available it will be wiser

to control the tempering heaters by means of dampers, preferably of the interlocked double type operating in a slow or intermediate manner and reducing positively the air volume through the heaters as they increase the air volume through the by-pass around the heaters. Under this condition no diaphragm valves will be placed on the tempering heater supply and return connections.

Air Washers

The air washer should invariably be placed between an outer tempering heater capable of warming the air above a freezing temperature, preferably controlled by an outside thermostat, and an inner tempering heater capable of warming the conditioned air to the desired delivery temperature and controlled by a thermostat in the duct on the discharge side of the fan. It is never advisable to use a by-pass damper around a tempering heater in front of an air washer, since the cold air might cause freezing.

Control of humidity is possible by adjustment of the temperature of the air as it meets the water, and in greater refinement, by control with an additional thermostat, of the water temperature, cooler for lower relative humidity, possibly from a refrigerated supply; and warmer for a higher relative humidity, possibly from a heated supply.

Room Temperatures

The room temperatures are controlled by individual thermostats, operating valves on the radiators, and mixing dampers in the flues, as may be necessary. If a vacuum system of steam circulation is installed, the room thermostats should be intermediate or slow moving, while if steam circulation is by single-pipe or any kind of gravity system, the radiator valves should be operated quickly from full open to full closed. It is important that the mixing dampers in any case shall be moved slowly and held in intermediate positions.

If there is any room which has a separate supply fan and heating equipment, such as an auditorium or gymnasium heated by warm air and without radiation, as is often convenient and desirable, it is advisable to provide against cold drafts by a variation in the above arrangement, as follows:

Suppose that there is a fan drawing through a heater composed of five layers, and delivering air directly to an auditorium, or to a picture theatre. The thermostat in the room ordinarily will strive to keep the room cool. If there are many occupants and many artificial lights, the problem will be to keep cool rather than warm, and the room thermostat, in a temperature above that at which it is set to operate, will ordinarily shut off all heat, while the fan will deliver unheated air. In a room at 80 deg. the admission of air colder than about 70 deg. (depending on the point of entry) will cause discomfort from drafts.

The prevention of this unfortunate situation is achieved by installing two thermostats, one in the room and one in the air duct, the room thermostat serving merely to admit air to the duct thermostat. When the room is cool, both thermostats will be closed and warm air will enter. When the room temperature gets to the critical point of the room thermostat, the room thermostat opens, passing air to the duct thermostat. The duct thermostat may be set to permit this air to pass on by and to function at the heater to reduce the temperature, but will be set so that when the duct temperature lowers to the critical point of the duct thermostat, the latter takes control and prevents the entering air from getting so cool as to cause drafts.

Unit Systems

These individual fan-radiator units are usually equipped with highly efficient radiators in one section, having one supply and one return valve, and depend on nicely adjusted dampers for mixing the heated air with unheated air to gain a desirable admission temperature. In the milder climates, it is necessary to operate steam supply valves with thermostats arranged to close after mixing damper has been completely closed. Some unit heater manufacturers are furnishing two sets of heating coils in the unit heaters so that one coil may be used as a tempering coil. The approved procedure is to use an intermediate or slow acting room thermostat for operating the mixing dampers in the unit. This thermostat may also operate the radiator valves if a vacuum system of steam circu-

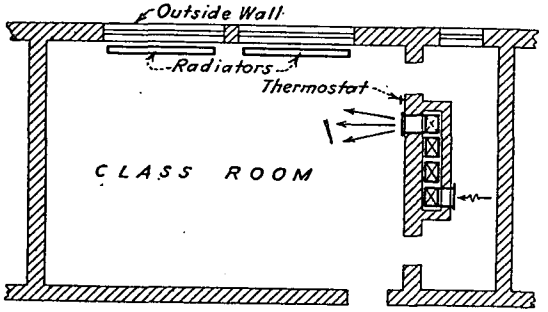


FIG. 3. PLAN OF CLASS ROOM IN AN ELEMENTARY SCHOOL, SHOWING LOCATION OF THERMOSTAT

lation is provided. If the steam circulation is single-pipe, or any kind of gravity type, the direct radiators should have positive thermostats.

The fresh air intakes to the units should be closed when the building is unoccupied, and the human operator cannot be trusted, especially in an installation comprising many units, to do this by manual means at each unit. An excellent recourse is to handle these cold-air intake dampers by a compressed air line running from the control point, say in the boiler room, which by manual opening of a valve permits air to pass to all of the units and to open all of the inlet dampers, the arrangement being such that the dampers will always be held shut by springs or weights when no air is permitted to pass or when the air compressor is shut down.

Direct-Indirect Radiators

Direct-indirect radiators are usually housed in, having cold-air inlets at their bases, and give rather a make-shift type of ventilation. It is not practicable usually to install mixing dampers, such as are used with fan-units, in these, and since the heating surface is in a single radiator calculated for the coldest air inlet temperature, regulation is difficult. The best results are obtained, where the use of direct-indirect radiators is necessary, by installing slow acting thermostats on special brackets directly above the radiators where the thermostat will be exposed to the air currents from the outside, and arranging for these to receive air only

through additional thermostats placed in the room and controlling the direct radiators. There should be a vacuum system of steam circulation, and the thermostats should be of slow or intermediate acting type, operating on the supply valves to the radiators.

Hot-Water Radiators

Hot-water radiators lend themselves to automatic heat control, especially where the circulation of water is of the forced type, but as the radiators heat and cool rather slowly, there will be some temperature fluctuation or range at the thermostat, especially when the radiator

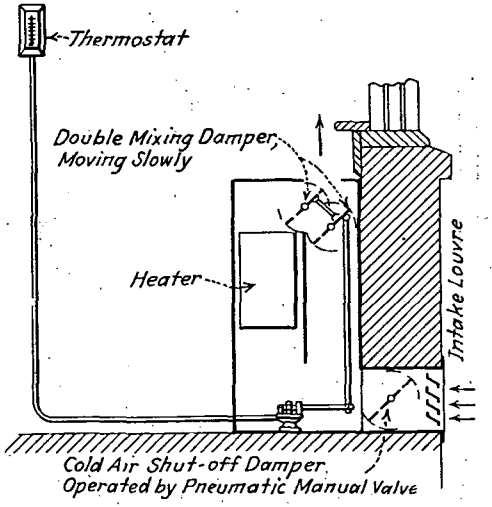


FIG. 4. DIAGRAM OF A METHOD OF CONTROL FOR A UNIT VENTILATOR

surface is excessive in amount. It is wise to use supply valves which will close tightly and to place lock-shield valves on the return ends of radiators, to facilitate repairs, and the lock-shield valves may prove invaluable in equalizing with great nicety the circulation.

In residence heating with hot water it often suffices to install a general thermostat in some representative room, which controls the draft, as with coal, or which controls the fire, as with gas or oil, but there should always be furnished in addition a thermostat in the water or circulating medium which will reinforce the general thermostat and which will prevent boiling over in case the general thermostat should be subjected to unfair exposure, such as an open window.

Warm-Air Heating Systems

With warm-air heating from furnaces, with fans, as in public buildings, it is always necessary to provide a supply of tempered air for cooling after the rooms become warm. A duct thermostat and dampers easily and positively will accomplish this, either by mixing some cold air with

heated air from the furnaces in an intermediate chamber, or by injecting some hot air from the furnaces into the cold air at the fan inlet, recirculating a measured and controlled part of the air around the furnaces. The room temperatures are controlled by intermediate thermostats and double mixing dampers the same as for a steam system.

Warm-air heating for residences may be controlled by a general thermostat in a representative room, and again, as with hot water, an additional thermostat at the furnace in the warm-air chamber is desirable to reinforce the general thermostat.

Service Hot Water

It is safe to say that no service hot-water heater should ever be installed without automatic heat control. Automatic heat control for this service not only saves fuel, but also prevents scalding and damage to materials. It also brings about a great reduction in maintenance of valves, pipes,

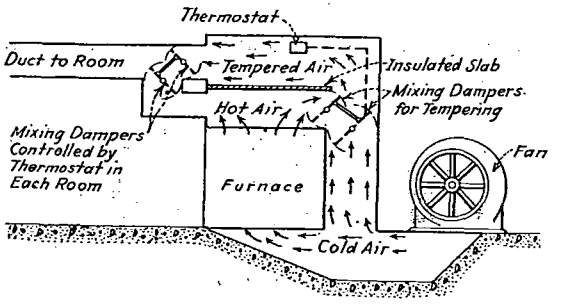


FIG. 5. AN ARRANGEMENT FOR TEMPERED AIR WITH WARM AIR FURNACES

and fixtures. A unit type thermostat is most desirable, since it will function whether or not the general mechanical apparatus is in service, and will control steam and return valves or draft dampers, oil or gas fires, or electric heaters.

In hotels, hospitals, and similar institutions, there should always be at least two independent water heaters, one having very hot water for kitchen uses, the other having water of medium temperature for bath and lavatory purposes, both controlled automatically. Thermostatic anti-scalding devices are available for showers and the like, but these will not prevent the great heat waste due to maintenance of scalding temperatures for bath water. No kitchen administration is satisfied without very hot water, but this demand is intermittent and small in volume as compared with usual bath and lavatory demands.

Oil Burner Control

No oil burning apparatus, unless provided with automatic heat control, can compete in operating cost with coal. An approved method for residence heating with oil is to install the following combination:

1. A general thermostat in a representative room, controlling the electric supply to the burner motor.
2. A second thermostat in the boiler or furnace which will take control should No. 1

thermostat fail to prevent improper or unsafe temperature being maintained inside the heater.

3. A third thermostat at the gas pilot which, unless kept warm by the pilot flame, will bring about the opening of the main switch to the burner motor, thus insuring that no fuel shall be injected unless a flame is in being surely to ignite it.

There are many other combinations for giving assured protection with oil burners other than thermostatic devices, such as pressure and weight-actuated mechanisms, but it is doubtful whether they are as reliable as the thermostatically controlled schemes.

Where electric ignition for the intermittent oil spray is used, it is safer to provide for a continuously operating spark, and to have a thermostat in the heater which will cut out the main switch if the temperature ever gets lower than the critical point which indicates failure to ignite the spray.

Gas Burning Appliances

The same high intensity as with oil fuel makes it necessary to depend on thermostats to prevent waste, and the intermittent operation and

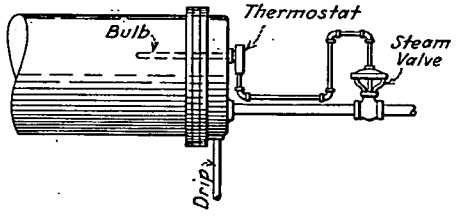


FIG. 6. THERMOSTAT ON STORAGE WATER HEATER

Note.—Connected to special heavy duty water heater and regulating temperature of water by flow of steam in coils. Flow of steam controlled by temperature of water to be heated.

necessity for a pilot flame makes it wise to install for gas the same combination of three thermostats as for oil burners, one on the general service, one in the heater, and one on the pilot flame.

Automatic Fuel Burner Control for House Heating and Water Heating

The automatic burning of fuel for house heating has made rapid progress within the last decade, and it may be said this entire industry is basicly dependent upon automatic heat control. Liquid fuel such as oil, solid fuel such as certain coals, and gas are all responsive to automatic control through what might best be called a system of controls. The thermostat on the wall, of say the living-room, is the master device but may be made inoperative through the functioning of one or several other devices more properly called safety devices. These are all more or less well understood.

In practically every home there are two primary heat requirements, that of warming the house and that of heating water for domestic needs. One automatic fuel burner may perform this double function and thus give service through the entire year.

Fig. 10 shows typical arrangement of installation employing standard boiler, fuel burner, indirect water heater, storage tank with thermostat

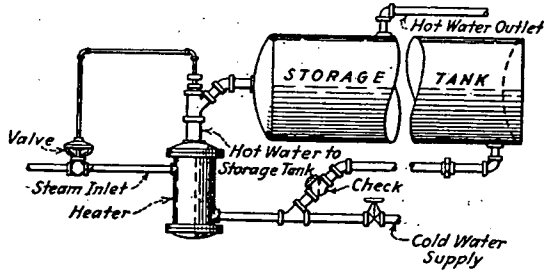


FIG. 7. THERMOSTAT ON AN INSTANTANEOUS WATER HEATER AND STORAGE TANK

Note.—Controlling supply of steam to an instantaneous water heater and storage tank. Control of steam to heater maintained by temperature of water in tank.

and control valve with thermostat, with the added safety controls to fit the fuel burner employed.

The thermostatic heat controls consist of room thermostat and tank thermostat.

These thermostats are so interconnected that *readiness to serve* on the part of the fuel burner is maintained while both or either heat or hot water is wanted. When no heat for warming is wanted the room thermostat simply closes the heating equipment off and the burner continues to maintain the hot-water supply, and that at very satisfactory efficiency. The tank thermostat closes the burner off whenever the heating valve to the house is closed and the water in the tank is at the temperature for which it is set. There is a pressurestat for closing the burner off when the steam pressure reaches a certain point.

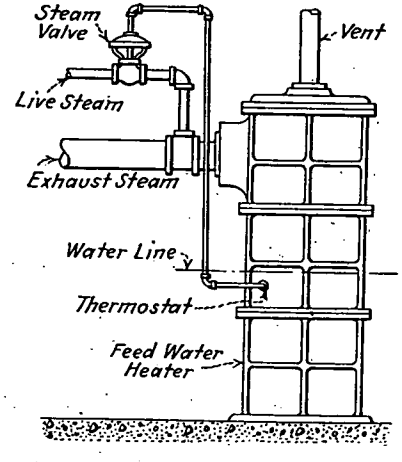


FIG. 8. THERMOSTAT ON AN OPEN FEED WATER HEATER

Note.—Regulating temperature of feed water by injection of live steam to supplement exhaust steam, controlled from temperature of feed water.

One heat equipment in this way takes the place of two.

A steam heating coil with an automatic control valve may also be added to hot-water tank so that the water in the tank may be heated by steam so long as any steam is present in the boiler, thus avoiding the contingency of having to run the burner for heating the water by the slow process of heat transfer from the water in the boiler to the water in the tank at such times as steam is not required in the house.

An aquastat may also be added to a steam heating boiler for limiting the temperature of the water in the boiler to a degree below the boiling

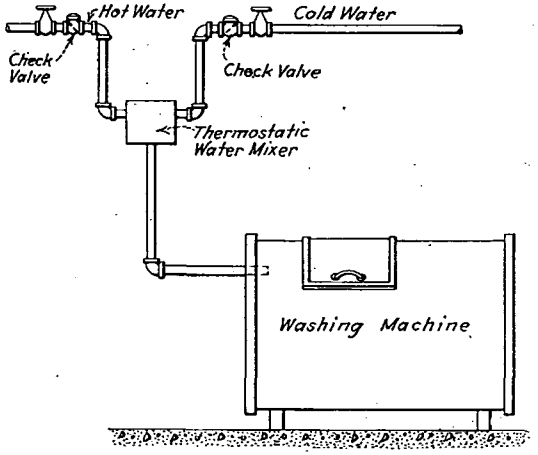


FIG. 9. WATER TEMPERATURE CONTROL FOR LAUNDRY MACHINERY

Note.—WASHING OF WOOLENS BY LAUNDRIES. A Thermostatic Water Mixer installed on the pipe line to a wash wheel will automatically deliver water of the exact temperature required properly to wash woolens. No matter how hot or how cold the water is admitted to the mixer, or whether the pressure of either varies, the temperature of the water delivered to the wash wheel will remain constant. Woolens should not be washed with water warmer than 80 deg. fahr.

point so that the apparatus may be used for heating the hot water at such times as steam is not required in the house. The connection between this aquastat and the electric control of the burner is arranged with a cut in and out switch so that its functioning may be cut in and out at will and in this way the heating boiler is used for heating water in summer or spring and fall without furnishing heat to the house.

An unique arrangement of control for a heating boiler is to have a coal fire operated from one end of the boiler furnace and controlled from a general thermostat operating the drafts and an auxiliary oil burner installed at the opposite end of the furnace controlled from an aquastat in the water of the boiler. With this system of control the coal fire may be made to take the burden of the load, but in case the coal fire is neglected or fails otherwise to meet the demand the oil burner automatically comes in. This makes a very reliable and economical arrangement where it is not desirable to use oil for the entire load on account of its cost.

Central Station Heating Control

Central plants should always be governed by thermostats as a measure of economy, and many public service companies require the installation of automatic heat control for this reason. Where economy is of greater consideration than comfort, it often suffices to install one unit type thermostat in a representative room, this controlling a main valve at the entrance to the building.

Where steam at appreciable pressure is furnished from a central station, a combination of pressure reducing valve and cut-off valve, controlled by a thermostat in a representative room, gives excellent results,

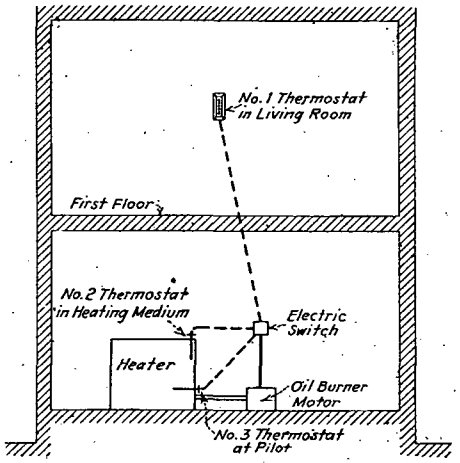


FIG. 10. TYPICAL ARRANGEMENT FOR OIL BURNER

as it automatically varies the steam pressure in the radiating surface within a considerable range, giving excellent regulation as well as economy. (See Chapter XI for further data on central heating system control).

Laundry Machines

Many laundry machines, especially for washing woolens, are improved wonderfully in service by the installation of automatic heat control.

By using automatic water mixers on the water supply pipe lines, water at the exact temperatures desired will always be delivered, no matter how hot the warm water may be, thus preventing the aggravating and expensive shrinking of woolen goods so common when water over about 80 deg. is used.

There is also a tremendous fuel saving by preventing overheating of all laundry water, while still insuring, by use of thermostats, that the water always shall be hot enough for each specific condition.

Refrigerating Units

In most buildings where refrigeration is used, common practice until recently at least, has been to install a central system, where cold brine is

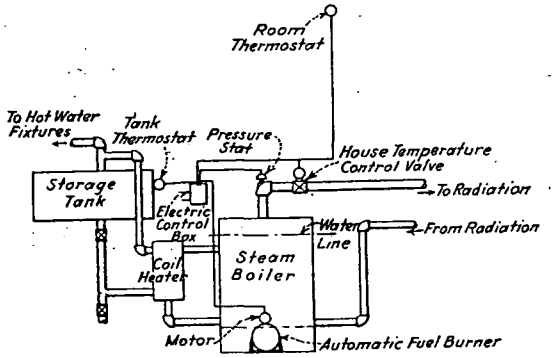


FIG. 11. TWO THERMOSTATS CONTROLLING AUTOMATIC ONE FUEL BURNER, ON DUAL SERVICE, HOUSE WARMING AND WATER HEATING

Note.—Usual safety controls to be used although not shown here.

produced, and which is pumped through insulated pipes to the various out-lying boxes.

Since the brine temperature is usually much lower than the desired temperature for many of these boxes, the automatic heat control of each unit is desirable and effects a considerable saving in operating cost.

Unit type thermostats are especially well adapted to this service and are available for control of such comparatively cool substances as drinking water, or storage compartments in ice boxes. The low temperature thermostats are placed in the water pipes or in the air chambers with balanced valves in the brine pipes, and automatic control, without attention and enduring for many years without adjustment, goes into effect forthwith.

The normal cost of producing refrigeration is approximately fifteen times, per degree difference in temperature, the cost of heating a given space. Products requiring refrigeration are often very sensitive to temperature fluctuations. It is, therefore, highly desirable to automatically control refrigeration sources both from the standpoint of economy in cost of producing refrigeration as well as in the safe guarding of the refrigerated products.

DOUBLE THERMOSTATIC CONTROL

A great majority of buildings are heated to normal temperatures from nine to 12 of the 24-hour per day for five days of the week. Many are so heated but six or seven hours Saturday and are not necessarily heated on Sunday, except to prevent freezing. This would indicate that a normal heating week would have 56 hours normal temperature out of 168 hours total or 33⅓ per cent. During the remainder of the time in many parts of the United States, it is necessary to have some heat to prevent freezing or excessive cooling.

It has been demonstrated clearly that it is more economical to carry a building at a temperature somewhat lower than the normal temperature

during the night and periods of non-occupancy than it is to allow the building to cool to a point that requires excessive pressure or heating effect to return it to normal temperature. It has been the practice to sub-divide heating mains so that heat may be furnished to parts of buildings which are occupied during periods when the building is not completely occupied. In this manner, the major portion of the building may be dropped to its economical *unoccupied* temperature.

Thermostatic equipment is now available to satisfy this demand in that each thermostat is provided with two separate temperature sensitive elements either one of which may be selected at will from the boiler room or office of the building. One sensitive element is set at a normal or operating temperature, say 70 deg., while the second temperature sensitive element is set at any lower temperature which it may be desired to maintain at times when the normal temperature is not required, say 50 deg. This apparatus is furnished where desired with individual switches on each thermostat so that the occupancy of any room may restore the temperature of that room to the normal from the low temperature. Thermostats can be so grouped on the air piping that any series of rooms throughout the building may be operated simultaneously from a remote source without the use of separate steam mains and return piping. This apparatus is, therefore, available on many jobs at practically no extra cost when credit is taken for the separate steam mains.

The double system of automatic temperature control assists in maintaining any building at a uniform low temperature throughout the non-occupied period, thereby eliminating the excessive cooling in parts of the building remote from the steam source which are the first to cool and the last to heat. During the past few seasons, economies have been demonstrated amounting to 40 per cent over normal hand operation by the use of the double control apparatus. The double control system is applicable to factories where certain portions of the building must be maintained at a uniform temperature continuously or where operated overtime or unusual periods. It is also applicable to club, school and office buildings.

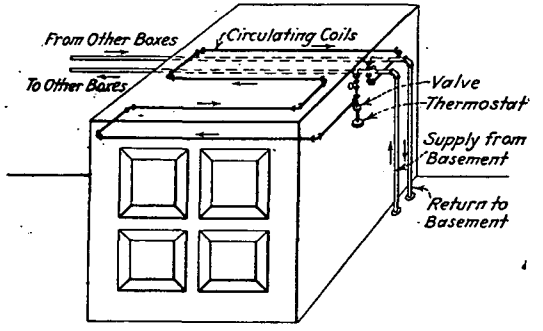


FIG. 12. UNIT THERMOSTAT

Note.—Unit Thermostat on brine refrigeration system automatically controlling flow of brine by temperature of air in box. This installation is also typical of rooms or driers heated by steam or hot water.

INDUSTRIAL APPLICATIONS

Automatic control of heat in manufacturing processes is believed to be still in its infancy. The promotion and development of automatic heat control was hard pioneering for many years. The reward for this pioneering seems to be in process of realization in the fabulous uses of thermostats in industry.

Without automatic heat control in innumerable manufacturing processes, what now are sure and perfect reactions would be only occasional successes, and the cost of production would be much higher.

In beet sugar making there are at least eleven processes where exact thermostatic control is imperative. In tanning leather there are at least fourteen such stages.

Without exact temperature and humidity control, no fine printing is possible, and no good weaving or dyeing is assured.

In the preparation of most food products automatic heat control is vital.

Thermostats prevent scorching in clothes dryers. They reduce evaporation and are a safety device for oil storage tanks.

They are essential to control gelatine temperature in making photographic films. They are used to control paraffin vats in making waxed paper, milk containers, etc.

They control baking ovens, no matter how the ovens are heated.

They are in use to an enormous extent in the drying and hardening of paints and enamels.

Automatic Control of Unit Heaters

The steady advance of the use of unit heaters for industrial heating has made automatic temperature control available with comparatively small expenditure in practically all buildings thus heated. Several general methods are in vogue; *first*, for small installations with single or, at the most, two or three unit heaters, a very satisfactory method is to use an electric thermostat operating through a relay or direct control switch; *second*, where a large number of unit heaters are furnishing ventilation as well as heat it is advisable to provide them with pneumatic control. The unit heaters may be controlled by means of the standard gradual acting type thermostats controlling steam supply which may be further supplemented with a pneumatic governor switch arranged to automatically shut off the heater when the temperature reaches a limiting degree.

An arrangement of this type where several unit heaters are furnishing heat for a single room will tend to keep the air in circulation and allow a few heaters to furnish the necessary heat with a minimum expense for electric current as well as for steam. With the last named arrangement, double automatic temperature control may be used which will automatically shut down all unit heaters during the non-operating period until the temperature falls below the safe operating point. Most of the floor type of unit heaters have a normal gravity circulating capacity about one-third of their heating capacity. This is enough to heat many buildings for average outside temperatures and also enough to overheat buildings for outside temperatures above the average. It is desirable,

therefore, to control the steam as well as the electric supply to floor type unit heaters.

Unit Control

Automatic control of temperature in any given space as for instance the warming of a room or a group of rooms may be accomplished in several ways. If several rooms are heated from one source and controlled with one thermostat the control may and probably should be called Group Control, or Zone Control, or Master Control, or possibly Service Control, but where each radiator or unit heater is controlled by individual thermostat the control may be called Unit Control and this type of control may be of the pilot type with thermo element relaying to control valve or of

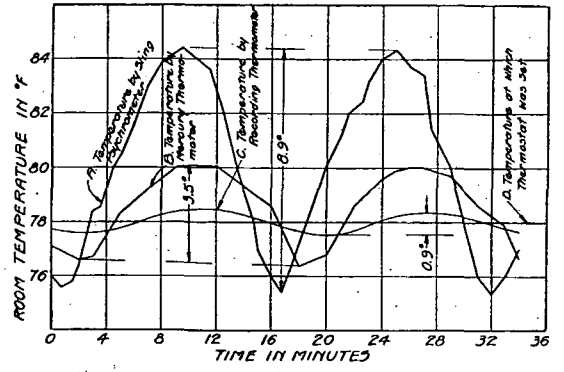


Fig. 13. Variations in Room Temperatures with Unit Control and Poor Circulation of Air

the self-contained type with thermo element an integral part of control valve.

Thermostatically Controlled Water Mixers

Hot and cold water may be thermostatically mixed to a predetermined temperature and delivered for various purposes ranging from the control of hydrotherapeutic hospital equipment to gang shower baths and various industrial uses where warm water of a specified temperature is needed.

This automatic water mixing is accomplished by an apparatus consisting of a shell enclosing a three-way valve operated by a thermostatic motor, the shell having hot and cold water inlets, an outlet for delivery, and a controller handle, or wheel, by which the apparatus may be adjusted for any desired delivery temperature.

A typical application of this thermostatic water controller is to have one connected in on the hot-water supply to a group of showers, the instrument being so arranged as to limit the hot-water temperature to a safe degree (usually 110 deg. fahr.) leaving it to the bather to mix as much cold water with it as he chooses through the ordinary hand valve.

Another application is to use four of these controllers on the hot-water

supply to a progressive or lane shower bath, such as is used in connection with swimming pools. The lanes are separated by perforated pipe railings directing horizontal sprays toward the center and the bathers on their way to the bath pass through four different temperature zones beginning with 105 deg. and ending at 60 deg. fahr.

PERFORMANCE AND REGULATION OF AUTOMATIC HEAT CONTROL

Variations in the performance of automatic heat control are sometimes misunderstood and in consequence the choice, regulation and care of such controls is improperly handled.

In order that a thermostat may function there must be a certain amount of temperature change in the medium being controlled; depending upon the sensitiveness of the control instruments and the rapidity with which the average change in the temperature of the medium, whose temperature is being controlled, is transferred to the medium surrounding the thermostat.

When the thermostat operates the steam or hot-water supply to a

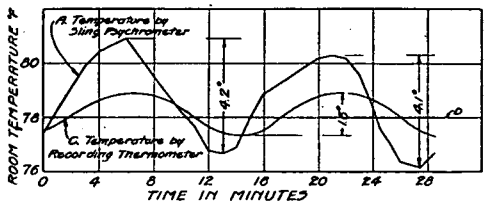


FIG. 14. VARIATIONS IN ROOM TEMPERATURES WITH UNIT CONTROL AND POOR CIRCULATION OF AIR

radiator or heater is automatically shut off or turned on, as the case may be, but some time must elapse before this takes effect upon the temperature of the medium being controlled.

When the supply of the heating medium is being cut off the remaining steam or water contents must condense or cool and when being turned on new steam or water must be supplied. In the first instance the material of the heater must be cooled and in the second instance it must be heated before full effect is exerted upon the medium being controlled.

The same principles are true of other systems of control such as for coal or oil fired boilers or furnaces, where the fire must be increased or decreased and the material and water in the boiler and system must be cooled or heated; for refrigeration, where the brine and materials in the system must be cooled or heated and in hot-water systems where the water and materials must be heated, before full effect is felt where the thermostat is usually located.

The operation of these and other such factors, over which the automatic control usually has no jurisdiction, tend to cause variations in the temperature of the medium being controlled, the amplitude and periodicy of which depend upon the heating medium, system and the sensitiveness of instruments.

In testing the accuracy of controls the sensitiveness of the thermometers, the movement of the medium around same also play an important part. All temperature measuring instruments have a lag due to the time required to heat their expansive media. Recording instruments have still more lag, due to the poorer circulation of the surrounding media. Sling instruments or instruments with forced circulation of the surrounding media are more sensitive than stationary ones.

Some of the later types of thin non-ferrous heaters have less lag than the older cast-iron types, which makes it more important to have good circulation of the medium being heated, between the heater and the thermostat, so as to prevent overheating when the heating medium is turned on and underheating when it is shut off.

Fig. 13 shows a case of the variation in room temperature produced by a temperature controlling and recording instrument of the vapor-tension, positive acting, unit type, controlling (by means of compressed air) the steam flow to a copper fan-blast reheater in a central air conditioning installation. The bulb of the instrument containing a volatile fluid was exposed in the room near the breathing zone. The room temperature had a definite cyclic variation resembling the sine curve wave. Curve (*A*) represents the room temperature fluctuation obtained by a sling psychrometer; curve (*B*) shows that recorded by an ordinary mercury ther-

TABLE 1.* TEST DATA ON PERFORMANCE OF TEMPERATURE REGULATORS IN ROOMS HEATED BY FAN BLAST HEATERS AND VENTILATED MECHANICALLY

THERMOSTAT NUMBER AND TYPE	AIR MOVEMENT AROUND THERMOSTAT	AIR CHANGES IN ROOM per HOUR	VALVE OPERATING MEDIUM	TYPE OF HEATERS CONTROLLED	VARIATION IN ROOM TEMPERATURE BY SLING PSYCHROMETER, DEG. FAHR.
Room or duct type:					
No. 1. Vapor tension, positive action, plain copper thermostatic bulb.	Still air	30	Comp. air	Copper blast heater	8.9
No. 1*a*. Same as above	650 ft./min.	30	"	"	4.1
No. 1*b*. Vapor tension, positive action, with capillary coil bulb.	Exhaust duct (680 ft./min.)	30	"	"	2.9
Room type:					
No. 2. Bi-metal expansion, positive action.	650 ft./min.	30	"	"	3.8
No. 3. Vapor tension, positive action.	"	30	"	"	3.9
No. 3*a*. Vapor tension, positive action.	"	30	"	"	4.8
Duct type:					
No. 4. Metal expansion, intermediate action.	Exhaust duct (680 ft./min.)	30	"	Cast iron blast heater	4.9
No. 5. Metal expansion, postive action.	"	6	"	"	5.0
Electric make and break type:					
No. 6. Liquid expansion.	650 ft./min.	30	Electricity	Copper blast heater	8.3

*From tests reported by C. P. Yaglou.

mometer located near the bulb of the instrument; curve (*C*) that traced by the automatic recording mechanism of the instrument; and straight line (*D*) the temperature at which the instrument was set.

The true fluctuation in temperature is about 8.9 deg. fahr. according to the sling psychrometer, although that shown by the mercury thermometer is only 3.5 deg. and that traced by the recorder about 1 deg.

Fig. 14 shows the extent to which the sensitivity of the regulator was increased by blowing air, at a velocity of 650 ft. per minute, over its bulb, all other conditions remaining the same. Equally good results were obtained by placing the thermostatic bulb in the exhaust duct leaving the room. This is a better arrangement, because the temperature of the air in the exhaust represents more nearly the average temperature of the room.

Table 1 gives data on the performance of several well known temperature regulators. Apparently thermostat 6 was not designed for the purpose for which it was tested.

In plenum systems of heating and ventilation, temperature fluctuations between 4 and 5 deg. fahr., are not of sufficient magnitude to produce discomfort, if the variation is partly above and partly below the proper temperature, so as to average the proper temperature, and if the oscillations in temperature occur frequently enough to avoid sensations of coldness or warmth. A systematic temperature variation of this order is, in fact, very agreeable because of its stimulating effect on the skin. However, little is now known concerning what should be the magnitude and cycle frequency, of such temperature oscillations. When these become known, the thermostat, in conjunction with mixing dampers, will probably lend itself remarkably well to controlling both of these factors.

In rooms ventilated spontaneously and heated by direct radiation, the problem of temperature control is much more difficult than in plenum systems. As a general rule, the tendency is toward overheating; because there is ample heating capacity—in fact too much for the average winter conditions—but no adequate means for cooling the room once it becomes overheated. The result is that the greater part of the temperature wave produced by the regulator lies above the proper room temperature and remains in this warm region too long, until the excess heat is dissipated to the air out-of-doors by transmission through the exposed wall and glass, or by opening windows.

Care should be taken to choose the most sensitive thermostat for this purpose, which should be set according to indications of the sling psychrometer.

Similar precautions should be taken in split systems of heating and ventilation. The temperature of the air delivered by the ventilation system should, under all conditions, be several degrees lower than the temperature at which the room thermostat is set. If this precaution is not taken, the duct thermostat might fall in synchronism with the room thermostat and produce overheating.

CHAPTER XVII

HEAT EXCHANGERS FOR WATER AND OIL

Factors in Heat Transfer, Critical Velocities, Variation of Heat Transfer, Design of Exchangers, Operating Quotations, Economics of Design.

IN problems of fluid friction and heat transfer to fluids, the concept of a fluid film has become of great use. This surface film varies in thickness with velocity and viscosity and, hence, heat transmission through the film, and friction drop of a flowing liquid are dependent upon these and other properties of the liquid. Results of various experimental determinations of friction drop and of heat transfer from the wall of a tube to a liquid flowing inside it are best correlated by the use of the Nusset type of equation:

$$\frac{hD}{K} = F\left(\frac{DV}{z}\right) f\left(\frac{cz}{K}\right)$$

where

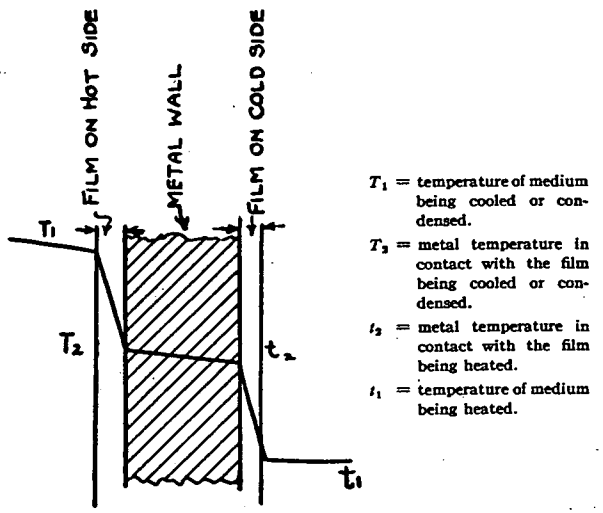
h = heat transfer coefficient.
D = diameter of pipe in inches.
K = thermal conductivity.
V = mass velocity.
z = viscosity.
c = specific heat.
F, f = functions of the groups of variables.

The various factors are arranged in dimensionless groups, and the effect of each group upon the heat transfer rate is found, based upon experimental results.

In general, there are two flow conditions of a fluid inside a tube. These are determined by its physical properties and the diameter, length and condition of the tube through which it flows. The velocity of the liquid past the surface is the major factor in film thickness, but since this velocity is difficult to determine, the average velocity of the fluid is used in calculations. For very low velocities or for high viscosity, the fluid may be considered to move as a series of concentric cylinders sliding in one another. Under this condition the friction drop of a liquid along a tube varies directly with the velocity, if viscosity remains constant. For this type of flow, the average velocity is approximately half the maximum

Material for this Chapter was prepared especially for THE GUIDE by D. J. Bergman, A. E. Krook and W. H. McAdams.

value found at the center. This condition is termed viscous or straight line flow. If the velocity be gradually increased and eddy currents set up, the average velocity becomes much greater than one-half the maximum, the friction drop increasing closely in proportion to the square of the velocity. This condition is termed turbulent flow, and the velocity at which the type of flow changes is called the critical velocity. The change is usually not well defined and often passes through an intermediate stage.



T_1 = temperature of medium being cooled or condensed.
T_2 = metal temperature in contact with the film being cooled or condensed.
t_2 = metal temperature in contact with the film being heated.
t_1 = temperature of medium being heated.

FIG. 1. TEMPERATURE GRADIENT THROUGH TWO FLUID FILMS AND METAL WALL

The critical velocity is a function of viscosity and density of the liquid and also of the pipe diameter. It is given as

$$v_c = \frac{0.122\,z}{D\,s}$$

where

v_c = critical velocity, feet per second.
z = viscosity in centipoises relative to water at 68 deg. fahr.
D = pipe diameter in inches.
s = specific gravity of liquid.

As an example, in a 2 in. pipe the critical velocities of water and a refined oil with a viscosity of 10 centipoises, or 63 seconds Saybolt Universal are, respectively, 0.059 and 0.65 ft. per second. These same liquids in a tube of ½ in. I. D. have critical velocities of 0.23 and 2.7 ft. per second.

In heat transfer equipment, the velocity should preferably be maintained above the critical value determined as above. Calculations based on data below the critical range are very unreliable, and also the heat transfer rate is low. There is always an additional turbulence set up near

the entrance and exit of a short tube, hence the heat transfer for a short tube is greater than for a long one.

Correlation of heat transfer data was delayed many years by the search for equations to fit overall coefficients. Greater progress was made by resolving the overall thermal resistance into parts and treating it in a manner analogous to an electric circuit. Temperature corresponds to voltage, heat flow to current, and thermal resistance to electrical resistance. The individual resistances of cooling film, metal, scale, and heating film added together give the total resistance, and the reciprocal of this sum gives the overall conductance or heat transmission coefficient. Fig. 1 shows the temperature relations existing during heat transfer through two fluid films and a metal wall.

U = overall heat transmission or conductance (B.t.u. per hour per square foot per deg. fahr).
H = total heat transmitted (B.t.u. per square foot per hour).
$h_c = \frac{1}{r_c}$ = conductance of cooling film (B.t.u. per hour per square foot per deg. fahr.)
$h_m = \frac{1}{r_m}$ = conductance of metal. (B.t.u. per hour per square foot per deg. fahr.)
$h_w = \frac{1}{r_w}$ = conductance warming film. (B.t.u. per hour per square foot per deg. fahr.)
$R = \frac{1}{U}$ = total resistance to flow of heat from heating medium to cooling medium.

$$r_c = \frac{T_1 - T_2}{H} \qquad r_m = \frac{T_2 - t_2}{H} \qquad r_w = \frac{t_2 - t_1}{H}$$

Adding the above equations

$$R = \frac{1}{U} = \frac{(T_1 - T_2) + (T_2 - t_2) + (t_2 - t_1)}{H} = \frac{T_1 - t_1}{H}$$

Any additional resistances, caused by scale or dirt, should be added to give the total resistance.

To obtain a value for the film resistance of a liquid flowing in a pipe, Morris and Whitman give a curve as the result of many experiments, which can be considered approximately a straight line, with the formula

$$\frac{h\,D}{K} = 0.83 \left(\frac{DV}{z}\right) \left(\frac{c\,z}{K}\right)^{0.37}$$

h = heat transfer for liquid film (B.t.u. per hour per square foot per deg. fahr.)
D = inside diameter of tube in inches.
K = thermal conductivity of liquid (B.t.u. per hour per square foot per deg. fahr. per foot thickness).
V = mass velocity (pounds per second per square foot).
z = viscosity in centipoises, relative to water at 68 deg. fahr.
c = specific heat (B.t.u. per pound per deg. fahr.)

If we let Q represent the quantity flowing through the tube, $Q = 0.005454\,D^2V$,

$$h = 1.52\,\frac{K}{D}\,\frac{Q}{D\,z}\left(\frac{c\,z}{K}\right)^{0.37} = 1.52\,\frac{Q}{D^3}\left(\frac{K}{z}\right)^{0.63} c^{0.37}$$

On this basis, it is seen that if other conditions remain constant, the rate of heat transfer increases directly with the quantity flowing, inversely

with the square of the tube diameter, and inversely with the 0.63 power of the absolute viscosity in centipoises. In this formula, c and z are taken at the temperature of the body of the liquid rather than at the temperature of the film.

A formula given by McAdams and Frost from experiments on water, using film temperature is:

$$h = \frac{15.4\,K}{D}\left(1 + \frac{50}{r}\right)\left(\frac{DV}{z}\right)^{0.8}$$

r = ratio of length of tube to diameter.

As an approximation, the above formula may be used for liquid flowing outside tubes by using four times the hydraulic radius for D. The

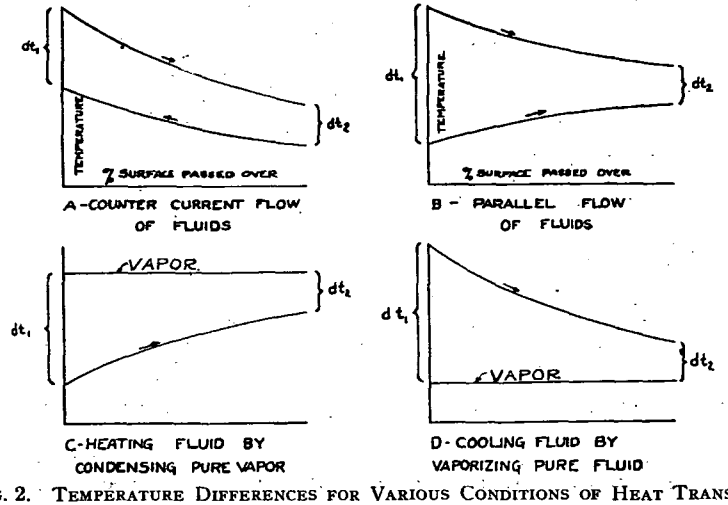


FIG. 2. TEMPERATURE DIFFERENCES FOR VARIOUS CONDITIONS OF HEAT TRANSFER

turbulence is usually much greater than is indicated by this means, especially when cross flow occurs.

The value of h found from the equations is, of course, only the heat transfer rate from the tube through one liquid film. If the problem to be considered is the transfer of heat from oil to oil, or from water to water, the reciprocals of the three heat transfers through heating film, tube, cooling film, and any scale or dirt, must be added to obtain the overall resistance.

In the absence of non-condensable gases, the coefficient of heat transfer from condensing steam to a tube may be from 1500 to 3000, or $r_s = 0.0007$ to 0.0003. Oil in the steam increases the resistance greatly and the resistance for condensing oil vapors, benzol, or other materials is much higher than for steam. The resistance of the tube wall to heat flow can be easily calculated, knowing the conductivity of the metal. It is based upon the logarithmic mean diameter of the tube, which can be taken as the arithmetic average diameter, with very little error in all ordinary

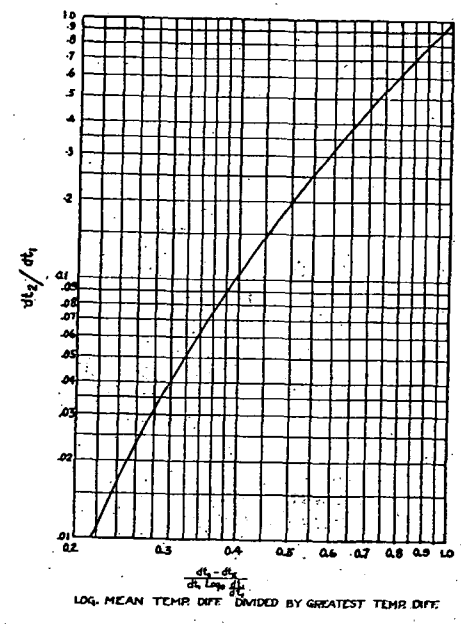


FIG. 3. CHART FOR CALCULATION OF LOGARITHMIC MEAN TEMPERATURE DIFFERENCE

cases. If a = thickness in inches, D_a = average diameter of tube, and K = heat conductivity in B.t.u. per hour per square foot per degree per foot thickness.

$$r_t = \frac{a}{12\,K} = \text{resistance of tube wall to heat flow.}$$

$$h_t = \frac{12\,K}{a} = \text{conductance of tube wall.}$$

Values of K are given in the following table for different metals. There is a slight variation in K with temperature, but this change can be disregarded in almost all cases.

	K
Silver	240
Copper	220
Aluminum	120
Bronze	64
Wrought Iron	26
Cast Iron	36
Steel	26
Lead	20

From the above table, the resistance of a copper tube ⅛ in. thick would be $\frac{0.125}{220 \times 12} = 0.000047$, while that of a steel tube of the same

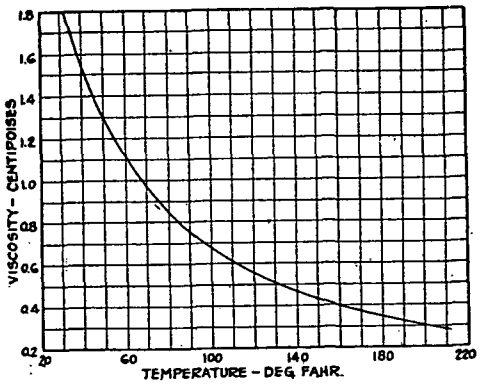


FIG. 4. VARIATION OF VISCOSITY OF WATER WITH TEMPERATURE

thickness would be $\frac{0.125}{25 \times 12} = 0.0004$. Compared with these values, the resistance of an oil film or a water film may be as high as 0.03 and 0.004 respectively, so that in steam heaters the overall resistance may often be assumed with little error to be equal to that of the liquid film only.

Having determined the individual resistances, they should be added, with corrections made to bring them all to the same unit of area where thick tubes are used. Thus, if the inside area of a pipe be accepted as a base, the resistance of the outside film would be multiplied by $\frac{D}{D_o}$ and the resistance of the tube by $\frac{D}{D_a}$.

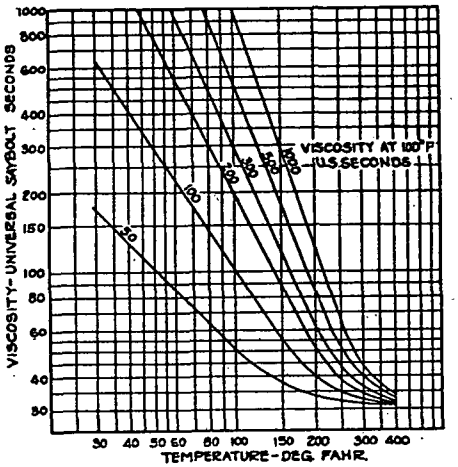


FIG. 5. VARIATION OF VISCOSITY OF PETROLEUM WITH TEMPERATURE

where

D = inside diameter of pipe in inches.
D_a = average diameter of pipe section in inches.
D_o = outside diameter of pipe in inches.

The next step is to determine the average temperature difference, which is the driving force. This value is usually a logarithmic function of the difference in temperature between the two fluids at entrance and exit of an exchanger.

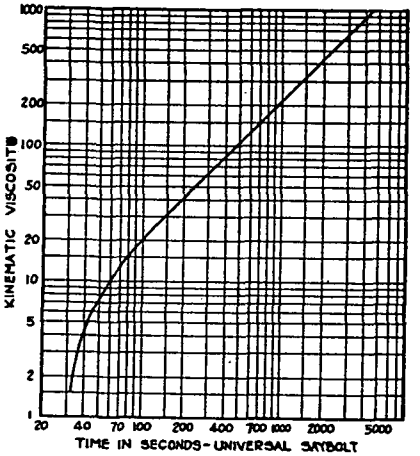


FIG. 6. RELATION OF SAYBOLT TIME AND KINEMATIC VISCOSITY = $\frac{\text{ABSOLUTE VISCOSITY IN CENTIPOISES}}{\text{SPECIFIC GRAVITY}}$

Fig. 2 shows temperature differences for counter-current flow, parallel flow, condensation of a pure vapor, and vaporization of a pure fluid.

The logarithmic mean temperature difference for each case in Fig. 2 is given as

$$\frac{dt_1 - dt_2}{\log_e \left(\frac{dt_1}{dt_2}\right)}$$

$\log_e$ = natural or hyperbolic logarithm.
dt_1 = greatest temperature difference.
dt_2 = least temperature difference.

A convenient curve for calculating the logarithmic mean temperature difference with a slide rule is given in Fig. 3, which gives the value of the above function divided by dt_1 for various values of dt_2. To obtain the logarithmic mean difference, multiply the value from the curve for a given ratio of $\frac{dt_2}{dt_1}$, by dt_1.

The viscosity of water changes with temperature, as shown in Fig. 4. If the viscosity of an oil at any given temperature be determined, Fig. 5

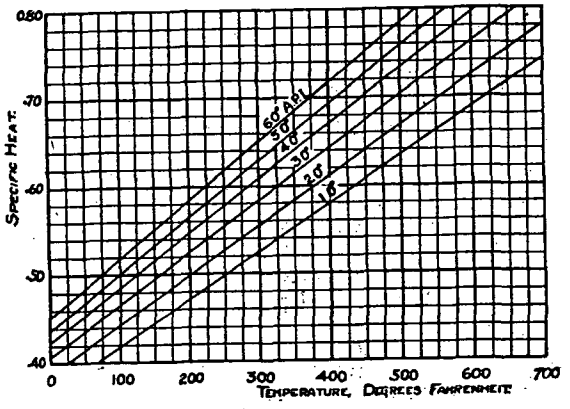


FIG. 7. VARIATION OF SPECIFIC HEAT OF PETROLEUM WITH GRAVITY

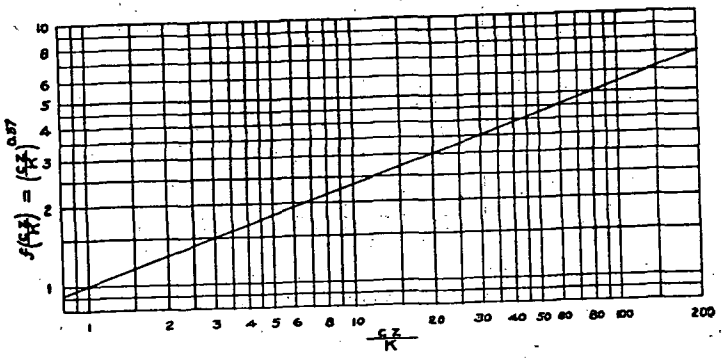


FIG. 8. VARIATION OF HEAT TRANSFER WITH $\frac{cz}{K}$

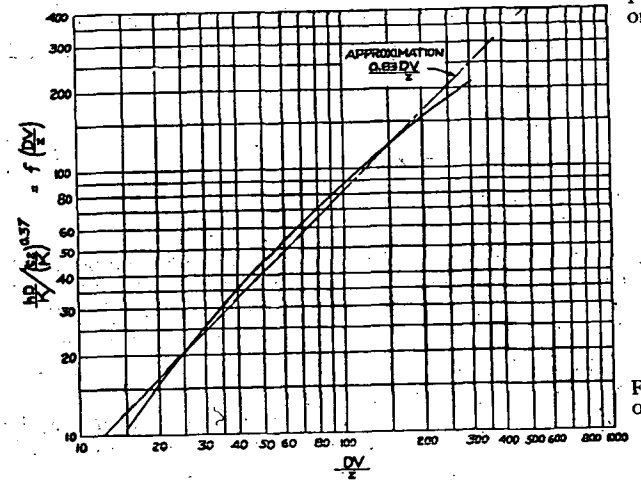


FIG. 9. VARIATION OF HEAT TRANSFER WITH $\frac{DV}{z}$

gives a convenient means of estimating the viscosity at any other temperature. Fig. 6 gives the conversion from Saybolt Seconds Universal, to kinematic viscosity which is absolute viscosity in centipoises divided by specific gravity. The viscosity of water at 68 deg. fahr., is one centipoise.

The heat conductivity K, for liquids, is usually assumed as a constant, but it is possible that improved results would be obtained if this were taken corresponding to the average main stream temperature. Data on the variation of K with temperature are scarce, but for water, an equation is given as $K = 0.304\ (1 + 0.00175\ t)$ where t is the temperature in degrees fahr. In the data of Morris and Whitman on oil (K) is taken as a constant with a value of 0.078.

The variation of the specific heat of oil with temperature has been investigated by many, especially in the lower ranges. Fig. 7 gives the results of the work by Fortsch and Whitman.

Figs. 8 and 9 give the results of the work of Morris and Whitman on heat transfer. In their work the end effect of the tubes was eliminated, and the properties used are those of the main stream. They recommend that values 25 per cent lower be used for cooling, and that a suitable correction be made for end effects.

As a check upon a given design, the following shows good general practice for the overall coefficient of heat transfer for different classes of apparatus, using tubular exchangers.

Condensing steam to water 300–500, Water to water 150, Steam to oil 75, Water to oil 50, Condensing oil vapors to water 60, Condensing oil vapors to oil 40, and Oil to oil exchanger 25.

The above figures can vary widely as they are naturally dependent upon individual conditions of velocity, viscosity, turbulence, diameter of tubes, and presence of scale, etc.

The design of the tube bundle in an exchanger should be made compatible with the available head. In this connection McAdams states that the friction drop in tubes when a liquid is being heated is lower than is expected from ordinary isothermal friction data. This is probably due to the reduction of the viscosity of the liquid film next the wall. As a rough indication of the magnitude of this correction the friction drop is reduced about 1 per cent for each 3 or 4 deg. fahr. temperature difference between wall and liquid, depending on the type of flow.

Many problems involve the transfer of heat to a relatively stagnant body of water, such as storage heaters. In this case, the velocity of the water due to convection currents is difficult to estimate, hence an assumption of the value of h must be made on the basis of experience. Tests on condensing steam in deep tanks with cast-iron sections have shown a value of h from 80 to 100, and a standard design of copper coil water heater is based on an average h of 120. Tests on similar oil heaters consisting of pipe-coils inside large tanks, show values of h from 4 to 20. This would depend greatly upon the viscosity of the oil.

OBTAINING QUOTATIONS

In obtaining quotations on heat exchange equipment, give as much data connected with the problem as possible. The more completely this

can be covered, the closer the design can be fitted to the requirements. The following outline may be followed:

1. Normal quantities of liquids and / or vapors.
2. Normal desired temperature of liquid and / or vapors entering and leaving.
3. Maximum and minimum temperatures.
4. Overload requirements.
5. Permissible friction drop (pressure drop each side).
6. Specifications of liquid.

For oil or other liquids, give specific gravity, viscosity, specific heat, latent heat, water content, wax content, sediment content, corrosive or erosive characteristics, temperature fluctuations, pressure pulsations. Give a distillation curve for petroleum, if possible, as vaporization of oil must be accommodated by vents, etc., to prevent vapor binding.

ECONOMICS OF EXCHANGERS

In the design of heat exchangers, there is always one set of conditions which will give the desired result at a minimum overall cost when initial investment, carrying charges, and operation cost are all taken into account. In some cases it does not pay to install a very efficient exchanger because the additional heat recovered over that which would be saved by a less efficient exchanger would cost more than heat brought in from an outside source. On the other hand, an exchanger may increase plant capacity out of all proportion to its cost, and this may justify an exchanger which would not be economical on a heat recovery basis only.

In general, the higher the velocity which can be allowed in an exchanger, the lower will be its cost for a given result. In many cases an exchanger is specified to give a pressure drop of 2 or 3 lb., when there is available 30 or 40 lb.

For further data on the design of heat transfer equipment a partial bibliography is given:

Principles of Chemical Engineering, Walker, Lewis & McAdams; Heat Transfer & Evaporation, Badger; Evaporating, Condensing and Cooling Apparatus, Hausbrand; Engineering Thermodynamics, Lucke; Proper Design and Operation of Heat Exchangers, Kallam & Semino; Oil Flow, Viscosity and Heat Transfer, Danforth; Heat Transfer for Oil and Water in Pipes, Morris & Whitman, *Ind. & Eng. Chem.* (March, 1928); Heat Transmission for Condensing Steam to Water in Surface Condensers and Feed Water Heaters, McAdams, Sherwood & Turner, *Trans. A.S.M.E.* (1926); Heat Transfer Symposium, *Ind. & Eng. Chem.* (May, 1924); A Graphical Method of Determining Heat Transfer in Pipes, McAdams, *Chem. & Met. Eng.* (October, 1927); Heat Transfer for Water Flowing Inside Tubes, McAdams & Frost, *Am. Soc. of Ref. Engrs.* (December, 1923).

CHAPTER XVIII

PUMPS AND TRAPS FOR HEATING AND VENTILATING EQUIPMENT

Boiler Feed Pumps, Automatic Pumps and Receivers, Centrifugal Pumps, Vacuum Heating Pumps, Connections for Pumps, Specifications for Pumps, Definition of Terms, Installation Data, Traps.

THE various kinds of pumps ordinarily used in connection with heating and ventilating installations may be classed under the following heads:

(1) Boiler feed pumps, (2) condensation return pumps, (3) return line vacuum heating pumps, (4) sump pumps, (5) forced circulation hot-water heating pumps, (6) circulating pumps for water, brine, etc., (7) refrigeration pumps and compressors.

BOILER FEED PUMPS

Boiler feed pumps may be of the following types: (1) direct acting steam-driven reciprocating pumps, (2) power-driven reciprocating pumps, (3) centrifugal pumps, (4) screw or other similar type pumps.

Capacities

The capacity of a boiler feed pump should be based on 3.45 lb. of water per hour per maximum boiler horsepower served, with a slippage allowance of 10 per cent in the water cylinders and a factor of safety allowance of *two* for intermittently operating pumps and *one and one-half* for continuously operating pumps, to provide for unusual conditions, such as low water in boilers, drop in steam pressure or excessive loads.

Piston Speeds and Efficiencies

For reciprocating boiler feed pump not to exceed 10 times the square root of the number of inches in the length of stroke of the water pistons.

Direct acting reciprocating steam driven or power driven boiler feed pumps are generally found to be more efficient for smaller installations especially with widely fluctuating loads as the efficiencies of centrifugal boiler feed pumps drop off very rapidly for the smaller sizes of pumps and for low load conditions. For this reason centrifugal pumps are not usually employed for installations of less than 1000 boiler horsepower.

Material for this Chapter of THE GUIDE was prepared especially by Otto E. Goldschmidt and P. M. Hunt.

Screw pumps may be used with good economy for small capacities.

Since the capacity and pressure at which screw pumps will operate is almost infinite, we can only give some idea of their capacity. Efficiencies range from 60 to 70 per cent.

TABLE 1. DIRECT ACTING STEAM DRIVEN DUPLEX RECIPROCATING BOILER FEED PUMPS

Dia. of Steam Cyl. in Inches	Dia. of Water Cyl. in Inches	Length of Stroke in Inches	No. of Strokes per Min.	Discharge in Gallons		Equivalent Dia. of Single Cyl. Pump	Boiler H. P. Served Without Factor of Safety	Size Pipe, Inches			
				Per Stroke	Per Min.			Steam	Exhaust	Suction	Discharge
3	2	3	70	0.04	5.6	2⅞	80	½	¾	1¼	1
4½	2¾	4	60	0.10	12.0	4	180	½	¾	1½	1¼
5¼	3½	5	50	0.20	20.0	5	300	¾	1¼	2	1½
6	4	6	50	0.33	33.0	5⅝	480	1	1½	2½	2
7½	4½	6	50	0.42	42.0	6⅜	600	1½	2	3	2½
7½	5	10	40	0.85	68.0	7	1000	1½	2	3	2½
10	6	10	40	1.22	97.6	8½	1400	2	2½	4	3
12	7	12	35	2.00	140.0	9⅞	2000	2½	3	5	4

TABLE 2. HORIZONTAL DUPLEX PISTON PACKED POWER DRIVEN BOILER FEED PUMPS FOR 100 LB. WORKING PRESSURE

Size of Pump Cylinders in Inches		No. of Revolutions per Min.	Displacement Gallons		Boiler H. P. Served Without Factor of Safety	H. P. Required to Drive Pump	Pipe Sizes Inches	
Dia.	Stroke		Per Rev.	Per Min.			Suction	Discharge
2½	4	30	0.34	10.2	148	1.5	1½	1¼
3	4	30	0.49	14.7	213	4.0	2	1½
3½	5	30	0.83	24.9	361	3.5	2½	2
4	6	25	1.30	32.5	471	4.0	3	2½
8	10	20	8.69	173.8	2520	18.0	5	4

TABLE 3. RECIPROCATING SINGLE ACTING POWER DRIVEN TRIPLEX BOILER FEED PUMPS FOR 150 LB. WORKING PRESSURE

Size of Pump Cylinders in Inches		No. of Revolutions per Min.	Displacement Gallons		Boiler H. P. Served Without Factor of Safety	H. P. Required to Drive Pump	Pipe Sizes Inches	
Dia.	Stroke		Per Rev.	Per Min.			Suction	Discharge
1½	2	50	0.045	2.25	33	0.40	¾	¾
1¾	2½	50	0.078	3.90	57	0.65	1	1
2	3	40	0.122	4.88	70	0.80	1¼	1
2½	4	30	0.255	7.65	110	1.15	1½	1¼
3	4	30	0.367	11.01	160	1.40	1½	1¼
4	4	30	0.652	19.56	280	2.6	2	1½
4	6	25	0.978	24.45	355	3.10	2½	2
5	8	20	2.041	40.82	592	5.00	3	2½
6	8	20	2.938	58.76	852	6.00	3½	3
8	10	20	6.520	130.40	1891	14.00	4	3

CONDENSATION PUMPS

Condensation return pumps are generally of one of the following two types: (1) automatic pumps and receivers, (2) continuously operating non-automatic return pumps.

Automatic Pumps and Receivers

The volumetric capacity of receivers for electrically-driven pumps should be not less than three times the maximum minute volumetric flow of condensation to be handled, measured between the high and low water lines in the receiver. For direct acting steam-driven pumps the receiver capacity may be less than for electrically-driven pumps.

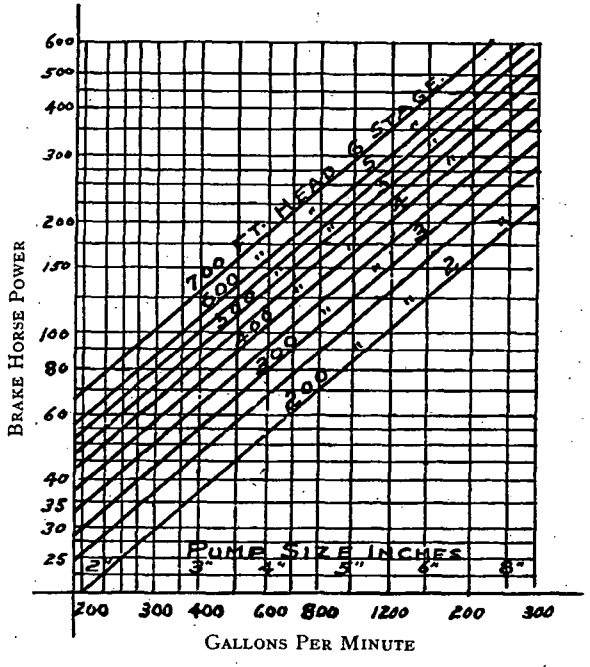


FIG. 1. FOR SELECTION OF SIZE AND STAGE OF CENTRIFUGAL BOILER FEED PUMPS

The piston speed in feet per minute should not be more than 10 times the square root of the number of inches in the length of stroke.

The volumetric displacement rate of water pistons should not be less than three times the maximum volumetric rate of the flow of condensate to be handled.

The normal capacity of centrifugal pumps should not be less than twice the maximum rate of flow of the condensate to be handled.

Table 4. Screw Pumps

Size	G. P. M.	Max. Rev.	Suction Inches	Discharge Inches
2	2– 15	1600	2	1½
2½	10– 20	1600	2	1½
3	20– 50	1600	2½	2½
3¼	40– 60	1600	3	2½
3½	55– 100	1500	4	3
4	85– 200	1400	4	4
5	175– 275	1200	5	4
5¼	200– 325	1200	5	4
6	275– 475	1200	6	6
7	300– 600	1000	8	6
8	450– 750	875	8	8
9	700–1000	720	10	10
10	800–1400	700	12	12
12	1200–2100	600	14	14
16	1750–4200	425	16	15

Continuously Operating Return Pumps

The piston speed in feet per minute should not be more than 10 times the square root of the number of inches in the length of stroke.

Table 5. Sizes, Revolutions per Min. Heads Pumped Against, Power Required and Boiler Horse Power for Several Commercial Sizes of Centrifugal Boiler Feed Pumps

Size of Pump Inches	Brake H. P.	Pipe Sizes Inches		Capacity Gallons per Min.	Boiler H. P. Served Without Factor of Safety
		Suction	Discharge		
Two Stage for 100 lb. Working Pressure					
2	13.3	2½	2	100	1450
2½	16.9	3	2½	150	2175
3	23.6	4	3	225	3262
4	37.2	5	4	400	5800
5	57.0	6	5	620	8990
6	76.5	8	6	900	13,000
8	125.0	10	8	1600	23,000
Three Stage for 150 lb. Working Pressure					
2	19.9	2½	2	100	1450
2½	25.4	3	2½	150	2175
3	35.4	4	3	225	3262
4	55.8	5	4	400	5800
5	85.5	6	5	620	8990
6	114.7	8	6	900	13,000
8	187.5	10	8	1600	23,000
Four Stage for 250 lb. Working Pressure					
2	33.2	2½	2	100	1450
2½	42.3	3	2½	150	2175
3	59.0	4	3	225	3262
4	93.0	5	4	400	5800
5	143.0	6	5	620	8990
6	192.0	8	6	900	13,000
8	312.5	10	8	1600	23,000

The volumetric displacement rate of water pistons should not be less than twice the maximum rate of flow of the condensate to be handled.

The quantities of condensate to be handled from direct radiation,

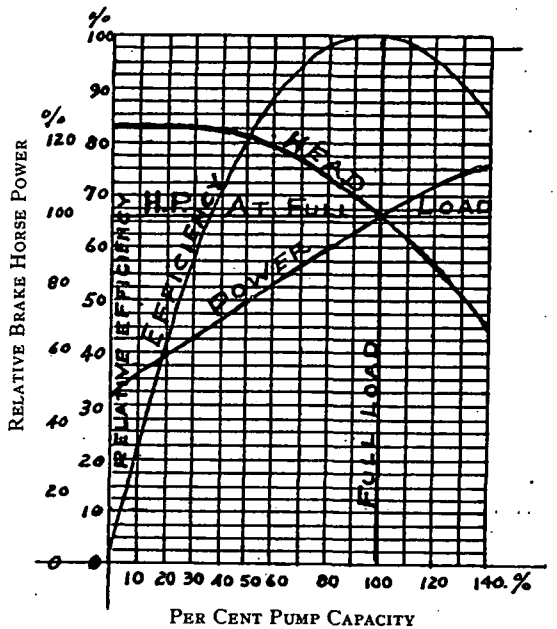


Fig. 2. Typical Characteristics of Centrifugal Boiler Feed Pumps

direct-indirect radiation and indirect or fan blast radiation may be estimated as follows:

For direct radiation $W = 0.3\ R^*$
For direct-indirect radiation $W = 0.6\ R^*$
For indirect radiation $W = \dfrac{Q \times 60 \times T}{55.6 \times H}$

where

W = pounds of condensate per hour.
R = square feet of radiation.
Q = cubic feet of air per minute.
T = temperature rise of air in deg. fahr.
H = the latent heat of steam in the system in B.t.u. per pound.

The normal capacity of standard centrifugal pumps should be based on condensate at a temperature of not over 180 deg. fahr. For temperatures of condensate above this the capacity should be increased as in Table 6.

*Note: that this is greater than the standard 0.25 lb. of condensate per square: oot, to take care of heating-up periods.

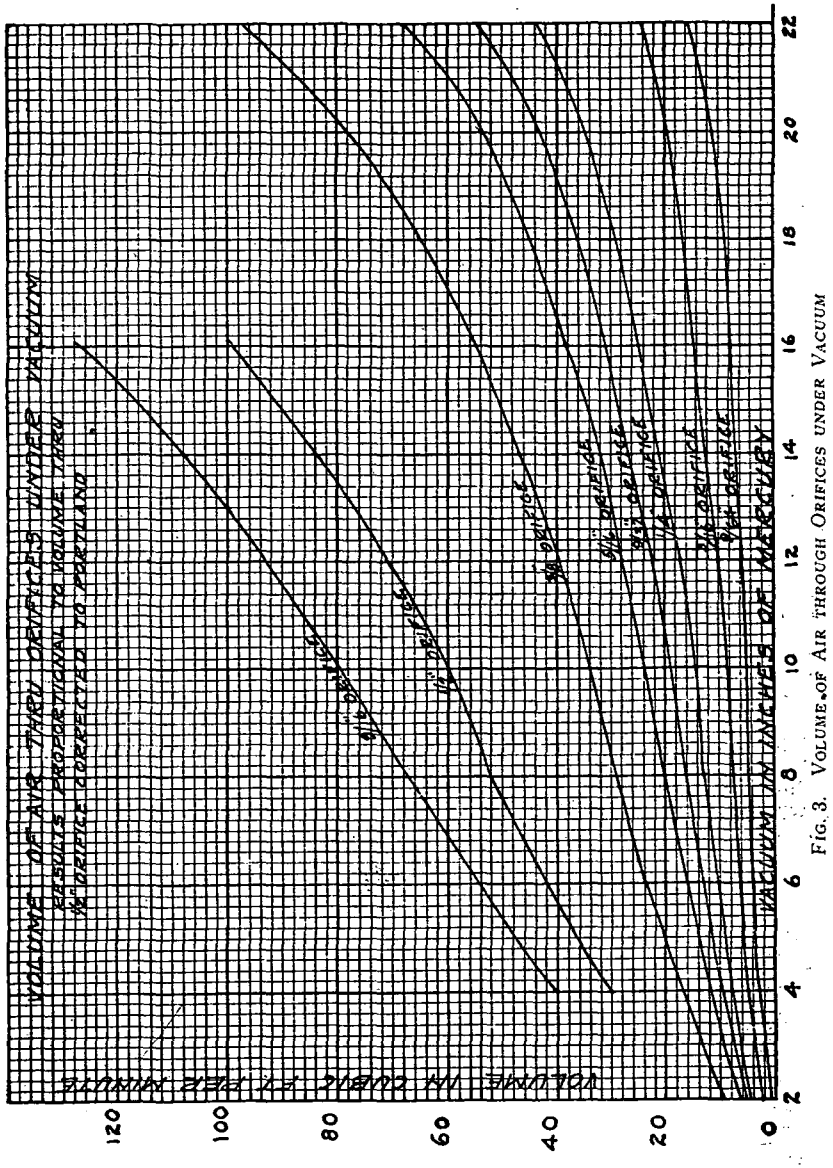


Fig. 3. Volume of Air through Orifices under Vacuum

The increase in pump capacity may be reduced if a static head above the pump suction is provided. When this static head is made equivalent to the absolute boiling pressure of the condensate (measured in feet of water) minus 12 ft., no increase in pump capacity is required. Such static suction head requirements may also be reduced about 50 per cent when special large suction inlets or special impellers are provided.

Sufficient head in addition to the total head necessary to overcome static head, velocity head, pipe friction and boiler pressure should be provided wherever condensate is to be returned direct to a boiler from the pump.

Table 6. Correction Factors for Standard Centrifugal Pumps for Temperatures of Condensate above 180 Deg. Fahr. at Pump Suction

Deg. Fahr.	Factor
190	1.15
200	1.56
204	2.00

Note.—To use Table 6, multiply the quantity of condensate to be handled by the factor corresponding to the temperature of the condensate at the pump suction and select a pump suitable for the quantity thus found.

Table 7. Duplex Piston Type Return Pumps with Receivers

Standard Pressure

Size of Pump	Receiver Capacity Gallons	Sq. Ft. Direct Radiation	Lb. Condensate per Hour	Minimum Steam Pressure
3 × 2 × 3½	12	6000	2000	50
4½ × 2¾ × 4	20	10,500	3500	40
5¼ × 3½ × 5	40	19,500	6500	35
6 × 4 × 6	60	30,000	11,000	35
7¼ × 5 × 6	100	45,000	15,000	30

Low Pressure

4½ × 2 × 4	12	6000	2000	25
5¼ × 2½ × 5	20	10,000	3500	20
6 × 2½ × 6	40	120,000	4000	15
6 × 3 × 6	40	180,000	6000	20
6 × 3½ × 6	60	290,000	9000	25

Table 8. Centrifugal Return Pumps with Receivers

Size of Pump Discharge Inches	Receiver Capacity Gallons	Sq. Ft. Direct Radiation	Lb. Condensate per Hour	H. P. to Drive	Total Head Ft.
1	40	12,000	4000	1	25
1½	60	25,500	8500	1½	50
2	100	42,000	14,000	2	50

VACUUM HEATING PUMPS

Return line vacuum heating pumps may be of the following types: (1) Direct acting reciprocating steam driven return line vacuum pumps; (2) reciprocating power driven return line vacuum pumps; (3) motor driven return line vacuum pumps, of the centrifugal or rotary type having one of the following arrangements:

TABLE 9. CHARACTERISTICS OF CENTRIFUGAL RETURN PUMPS AND RECEIVERS DELIVERING AGAINST 15 LB.

SIZE	SQ. FT. EQUIVALENT DIRECT RADIATION	GAL. PER MIN.	R. P. M.	ACTUAL H. P.	H. P. MOTOR SUPPLIED	FLOOR SPACE	SHIPPING WEIGHT
101	8000	11	1725	0.4	¾	5′ 3″x3′ 8″	700
102	16,000	22	1725	0.6	¾	5′ 3″x3′ 8″	700
103	26,000	35	1725	0.8	1	6′ 5″x3′ 8″	750
104	40,000	60	1140	1.0	1½	7′ 6″x4′ 2″	1050
105	65,000	90	1140	1.4	2	7′ 6″x4′ 2″	1100

TABLE 10. SIZES, SPEEDS, HORSE POWERS AND CAPACITIES OF MOTOR DRIVEN CONDENSATION RETURN PUMPS

Rating in Sq. Ft.	0–2000		2000–4000		4000–8000		8000–16000	
Discharge Pressure, Lb.	10	20	10	20	10	20	10	20
Gallons per Min.	3	3	6	6	10	10	20	20
H. P. Motor	⅜	¾	⅜	¾	⅜	¾	⅜	¾
R. P. M. 60 Cycle and D. C.	1700	1700	1700	1700	1700	1700	1700	1700
R. P. M. 25 Cycle	1440	1440	1440	1440	1440	1440	1440	1440
Shipping Weight	330	350	350	370	420	440	535	565

TABLE 11. MOTOR DRIVEN CONDENSATION PUMP CAPACITIES FOR DELIVERING AGAINST VARIOUS PRESSURES

RADIATION IN SQ. FT. OF DIRECT RADIATION	MINIMUM GALLONS PER MIN.	MAXIMUM BOILER PRESSURE LB.	MOTOR H. P.	SUGGESTED SIZE OF PIPING INCHES	RADIATION IN SQ. FT. OF DIRECT RADIATION	MINIMUM GALLONS PER MIN.	MAXIMUM BOILER PRESSURE LB.	MOTOR H. P.	SUGGESTED SIZE OF PIPING INCHES
4000	6–8	10	¼	1	15,000	25–30	10	¾	2
4000	6–8	15–40	½	1	15,000	25–30	15	1	2
4000	6–8	50–60	¾	1	15,000	25–30	20–30	1½	2
					15,000	25–30	40	2	2
					15,000	25–30	50–60	3	2
6000	9–12	10	¼	1¼	20,000	30–40	10	¾	2
6000	9–12	15–40	¾	1¼	20,000	30–40	15	1	2
6000	9–12	50–60	1	1¼	20,000	30–40	20	2	2
					20,000	30–40	30–40	3	2
					20,000	30–40	50–60	5	2
8000	12–16	10	½	1¼	25,000	40–50	10	1	2½
8000	12–16	15	¾	1¼	25,000	40–50	15	1½	2½
8000	12–16	20	1	1¼	25,000	40–50	20	2	2½
8000	12–16	30–60	1½	1¼	25,000	40–50	30–40	3	2½
					25,000	40–50	50–60	5	2½
10,000	15–20	10	½	1½	30,000	50–60	10	1	2½
10,000	15–20	15	¾	1½	30,000	50–60	15	1½	2½
10,000	15–20	20–30	1	1½	30,000	50–60	20	2	2½
10,000	15–20	30–40	1½	1½	30,000	50–60	30–60	5	2½
10,000	15–20	50–60	2	1½					

(*a*) One pumping unit and motor for handling both air and condensate.

(*b*) One pumping unit and motor for handling air and a separate pumping unit and motor for handling condensate.

(*c*) One pumping unit and motor for handling condensate with an air ejector operated by a recirculated portion of the condensate for handling the air.

(*d*) One pumping unit for handling condensate and another for handling the air, both operated by one motor.

The volumetric displacement rate of the water cylinders of steam or power driven reciprocating return line vacuum pumps should be from 8 to 10 times the volumetric rate of flow of the condensate to be handled.

The piston speed in feet per minute of steam or power driven reciprocating return line vacuum pumps should not be more than 20 times the square root of the number of inches in the length of stroke.

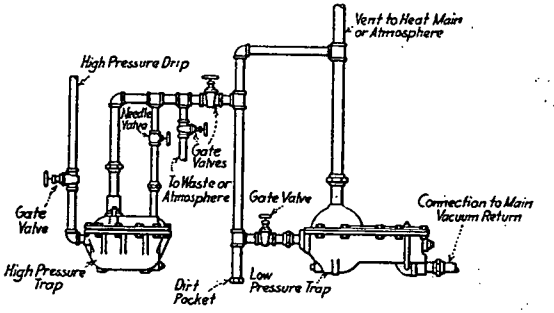


FIG. 4. METHOD OF DISCHARGING HIGH-PRESSURE APPARATUS INTO LOW-PRESSURE HEATING MAINS AND VACUUM RETURN MAINS THROUGH A LOW-PRESSURE TRAP

The speed of crank shafts of power driven reciprocating return line vacuum pumps should not exceed 40 r.p.m.

The type of drive to be employed between motor and pump may be chain, belt or gear. When gears are used they should be of a type which will be quiet in operation.

The receiving tank may be placed either on the suction or on the discharge side of the pump; generally on the suction side of centrifugal or rotary pumps and on the discharge side of reciprocating pumps.

The capacity of receiving tanks, when placed on the suction side of pumps, should be proportioned to the operating condition to be met. To this end its capacity should be such as to retain the condensate and to take care of fluctuations between the rate of returning condensate and the rate of the pump delivery. This capacity in case of automatically controlled units should be the capacity of the tank in gallons between the high and low water levels in the tank, as determined by the water line control, and when not otherwise provided for, should be in accordance with Table 12.

Air capacities of vacuum heating pumps are in general referred to as equivalent cast-iron direct radiation, and may be assumed on a decreasing

ratio as the system increases in capacity, in accordance with Table 13. It should be noted that while water capacities of pumps for fan blast heaters are to be based upon their equivalent in direct radiation the air capacities for this class of radiation may be considerably less than that corresponding to this equivalent.

The air capacity measurement of a vacuum heating pump should be made at a point in the main vacuum return line close to and before it enters the pump strainer, while the pump is in operation, under the

TABLE 12. RECEIVER TANK CAPACITIES FOR CENTRIFUGAL OR ROTARY VACUUM HEATING PUMPS

SQ. FT. EQUIVALENT DIRECT CAST IRON RADIATION	TOTAL RECEIVER TANK CAPACITY IN GALLONS	RECEIVER TANK CAPACITY BETWEEN HIGH AND LOW WATER LIMITS WHERE AUTOMATIC WATER LINE CONTROL IS USED.
8,000	28	20
16,000	33	24
26,000	40	29
40,000	49	35
65,000	63	47
100,000	80	63

vacuum specified at the pump suction and while handling the quantity of condensate specified at a temperature not exceeding 180 deg. fahr.

Air test in general may be made with water at lower temperatures; these determinations shall be made by means of a standard test orifice located in an inlet connection to the pump suction, consisting of a plate ⅛ in. thick with a reamed hole having sharp edges and of a diameter corresponding to the capacity of the pump.

TABLE 13. AIR CAPACITIES FOR VACUUM HEATING PUMPS

SQ. FT. DIRECT EQUIVALENT RADIATION SURFACE	DIAMETER ORIFICE VAC. 10 IN.	AIR CAPACITY CU. FT. PER MIN.
8,000	9/64″	5
16,000	3/16″	9
26,000	1/4″	15
40,000	5/16″	19
65,000	3/8″	34
100,000	1/2″	60
150,000	9/16″	80
300,000	Three (3) ½″	180

Fig. 3, may be used to give the quantity of air handled, corresponding to several sizes of orifices and different degrees of vacuum to be met.

The water capacity of vacuum heating pumps, when operating against 8 in. of mercury vacuum, should be not less than ⅔ lb. of water per hour per square foot of equivalent cast-iron direct radiation, based upon condensate at a temperature of not over 180 deg. fahr. when the pump is delivering water against a specified gage pressure at the water discharge of the pump. For pumps handling both air and water the above water capacity must be delivered when the pump is maintaining a vacuum of 8 in. of mercury and handling air through a standard orifice corresponding to the air capacity of the pump as herein specified.

In estimating the water capacity no additional allowance need be made for covered mains or risers, but exposed mains or risers used as heating surfaces should be included in computing the equivalent square feet of direct radiation.

Steam driven vacuum pump size determination should take into consideration the following variables:

(*a*) The degree of tightness of system, (*b*) the efficiency of the radiator traps, (*c*) the temperature of the condensate at the pump, (*d*) the probable cooling effect of the return piping, (*e*) the use of lift points in the return, (*f*) vacuum to be maintained at the pump, (*g*) introduction of large volumes of high temperature water into the return piping near the pump, (*h*) the use of long runs of piping from the source of steam supply to the farthest radiator.

High-pressure traps should not discharge directly into a vacuum return because of the vapor formed by the re-evaporation of a part of the hot condensation.

Fig. 4 shows one method which may be used for disposing of the greater part of the vapor of re-evaporation.

TABLE 14. DIRECT DOUBLE ACTING STEAM DRIVEN RECIPROCATING VACUUM PUMPS

DIAMETER IN INCHES WATER CYLINDER	CONDENSATION LB. PER HR. FOR PUMPS WITH STROKE EQUAL TO BORE	DIRECT CAST IRON RADIATION SERVED	PIPE SIZES		DISCHARGE IN.	PUMPS HAVING UNEQUAL STROKE AND BORE	
			Steam In.	Suction In.		Stroke ÷ Bore	Capacity Factor
3	510	1700	½	1¼	¾	2.50	1.58
4	1047	3490	½	1½	1	2.25	1.48
5	1830	6100	½	2	1¼	2.00	1.38
6	2890	9633	½	2½	1½	1.90	1.34
7	4250	14,166	¾	2½–3½	1½–2	1.80	1.31
8	5920	19,733	¾	3–3½	2	1.75	1.29
9	7980	26,600	¾	3½–4	2	1.70	1.27
10	10,350	34,500	1	4–4½	2½	1.67	1.25
12	16,300	54,333	1	4½–5	2½	1.60	1.23
14	24,000	80,000	1¼	5–6	3	1.50	1.10
16	33,500	111,666	1¼	6–7	3½	1.40	1.15
18	45,000	150,000	1½	7	4	1.33	1.13
20	58,500	195,000	1½	7–8	4½	1.30	1.12
22	74,300	247,666	2	8	4½	1.25	1.10
24	92,300	317,666	2	8–10	5	1.20	1.08
26	112,800	376,000	2½	10	6	1.10	1.04
28	135,800	452,666	2½	12	6	1.00	1.00
30	161,300	537,666	2½	12	6	0.90	0.96
32	189,600	632,000	3	14	7	0.80	0.91
34	221,000	736,333	3	14	7	0.75	0.89
36	254,000	846,666	3	14	8	0.70	0.87
						0.67	0.85
						0.60	0.82
						0.50	0.78

Note 1.—The capacities given in Table 14 are for pumps having water cylinder with the length of stroke equal to the diameter of the water piston.

Note 2.—The capacities for pumps of a greater or less length of stroke may be found by use of the last two columns in this table as follows: Divide the stroke by the piston diameter and find the corresponding ratio in the column headed stroke ÷ bore. The capacity factor opposite this in the last column is then multiplied by the capacity given in the table to give the capacity of the pump in question.

Note 3.—When reciprocating pumps discharge against a head exceeding 5 lb. per square inch the pump stroke should exceed the bore to reduce the ill effect of clearance.

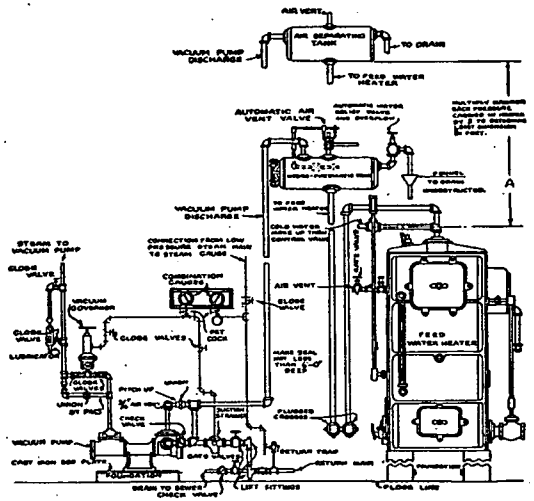


FIG. 5. METHOD OF CONNECTING VACUUM PUMP, FEED WATER HEATER AND SINGLE CONTROL HYDRO-PNEUMATIC TANK OR AIR SEPARATING TANK

Steam driven pumps can be economically used with steam pressures of 15 lb. or over and where the exhaust steam can be completely utilized.

Where the supply of exhaust steam from engines or other sources is continuously in excess of that necessary to supply the heating system the electric driven pump is generally the most efficient and is also preferable when the steam pressure is too low to operate a steam driven pump.

Steam cylinder sizes of reciprocating vacuum pumps should include the effect of frictional resistance of the piping system, the pump resistance and the possible drop in steam pressure under unusual conditions. When this analysis is not feasible the following formula may be used:

$$A_s = A_w 3 \left(\frac{\frac{V}{2} - P_d}{P_b} \right)$$

in which

A_s = area of steam piston in square inches.
A_w = area of water piston in square inches.
P_b = boiler pressure in pounds per square inch.
P_d = discharge pressure in pounds per square inch.
V = vacuum at pump expressed in inches of mercury.
$\frac{V}{2}$ = approximate vacuum in pounds per square inch (2 in. mercury = approximately 1 lb. per square inch).

Water cylinder sizes of steam driven reciprocating vacuum heating pumps may be determined from Table 14.

The discharge from reciprocating vacuum heating pumps should be provided with means for releasing the entrained air. This may require water

surface area in either a tank having a large horizontal cross section or a stand pipe of sufficient sectional area to permit a low velocity of downward water flow while the entrained air is escaping to the surface against the water current. For removal of air in a separating tank 1 sq. ft. of horizontal cross section for each 2100 lb. of water per hour should be provided. When a stand pipe is used for air separation, one with a diameter equal to that of the pump cylinder is usually sufficient.

The freely vented air separating tank is preferable wherever a suitable location is available. The tank should be located at such a height that the pressure produced by the water column in its discharge pipe will be sufficient to overcome that in the low-pressure boiler feed water heater or other point of disposal. Fig. 5 shows an arrangement which may be used for vacuum pump, air separating tank and feed water heater. This arrangement provides means for the air to escape through a vent in the top of the tank and for the water to flow by gravity to the feed water heater, through the loop seal attached to the discharge outlet of the tank. If the rate of flow of returns to the tank exceeds the rate of discharge from the tank the excess is permitted to overflow through an opening in the end of the tank, near the top.

The hydro-pneumatic type separating tank may be used whenever an open tank cannot be located at a height sufficient to provide gravity head to discharge the tank contents against the maximum pressure in the heater or boiler. A float controlled valve is placed on the air outlet of the separating tank and so arranged that when the water of condensation has insufficient head to flow by gravity to the point of use, the air will be confined in the upper part of the tank. Its operation is such that when the pump continues to deliver water and air to the tank the pressure within the tank increases until it becomes sufficient to discharge the water, thus lowering the water line and eventually permitting escape of the surplus air through the float-controlled air valve. The confined air pressure in the tank plus the gravity head in the tank discharge pipe must be sufficient to cause flow to the place of disposition. This confined

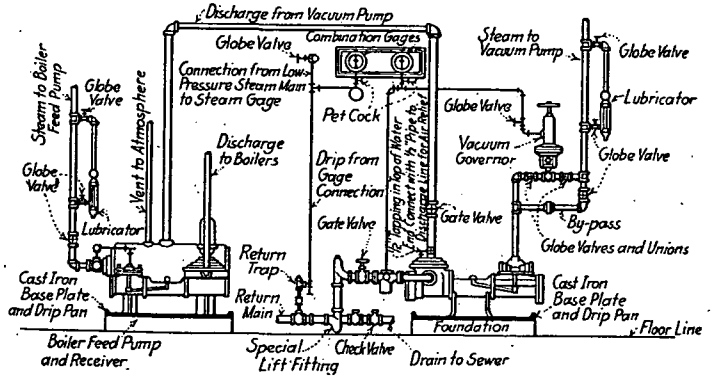


FIG. 6. METHOD OF CONNECTING VACUUM PUMP AND AUTOMATIC BOILER-FEED PUMP AND RECEIVER

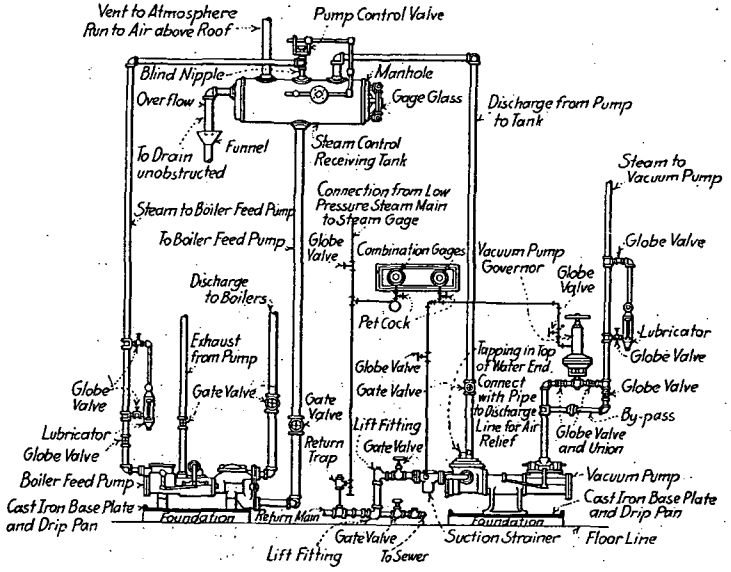


FIG. 7. METHOD OF CONNECTING VACUUM PUMP, BOILER-FEED PUMP AND STEAM-CONTROL RECEIVING TANK

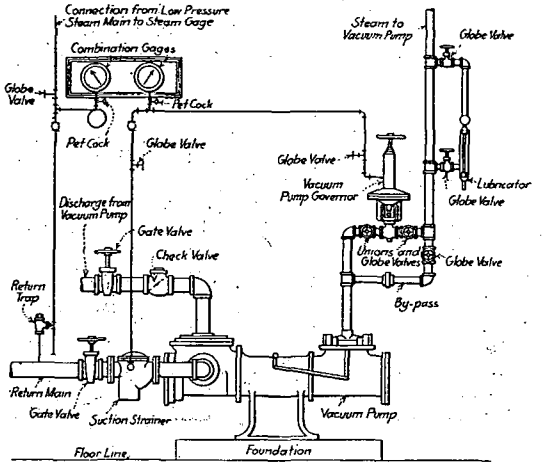


FIG. 8. METHOD OF MAKING CONNECTION TO STEAM-OPERATED VACUUM PUMP

air pressure plus the column of mixed air and water in the pump discharge to the tank constitute the total head against which the pump must act. Fig. 5 shows a hydro-pneumatic separating tank as well as a freely vented separating tank, for alternate use as conditions require.

Where the pressure in the heater, boiler, etc., varies materially from time to time and where it is desired to save energy by diminishing the head against which the pump shall work, a hydro-pneumatic type tank may be used, instead of a plain tank set at a higher elevation, to overcome the peak pressure in the boiler or heater.

Table 15 gives the size of plain and hydro-pneumatic tanks for air separating purposes and also those for storage of returns. In the latter case the tanks are based upon storing the quantities of water which will be discharged during five minutes at the basis of hourly rates given in the first column.

When the head on the delivery side of steam driven vacuum return pumps exceeds 15 lb. per square inch the condensate should be delivered to a vented receiver located close to the level of the vacuum pump outlet. This receiver should be connected to a separate steam or power driven water pump capable of delivering against the maximum head and should be controlled by a throttle valve or motor control, actuated by some suitable means, from the water line in the receiving tank.

Typical vacuum pump connections for several different conditions of service, are shown by Figs. 6, 7 and 8.

LIFTS

In vacuum heating systems where condensation is to be raised to a higher level it should be accomplished by means of lift fittings.

Lifts of 6 ft. or over should be made in steps rather than in one rise or through drag lift (consisting of long upwardly-inclined pipes.) In any case the pipes between the lifts should grade downward toward the pump.

TABLE 15. SIZES OF PLAIN AND HYDRO-PNEUMATIC SEPARATING TANKS

CONDENSATION POUNDS PER HOUR	FOR AIR SEPARATION ONLY		FOR AIR SEPARATION AND WATER STORAGE	
	Diameter Inches	Length Inches	Diameter Inches	Length Inches
4,000	12	24	24	36
6,000	12	36	24	48
8,000	18	30	24	72
10,000	18	48	30	48
16,000	24	48	30	60
24,000	30	48	36	60
	24	72	36	72
34,000	36	60	36	96
	36	72	42	72
45,000	42	60	42	96
	36	96	----	----
60,000	42	72	48	72
	42	96	48	96

SPECIFICATIONS FOR PUMPS

General.—Reciprocating and power driven pumps should be specified as to make, size, working water and steam pressures, piston speed, temperature of water to be handled, electric motor characteristics, and to insure economy in production, such standard practices as subsequently indicated.

The kind of drive should be specified for power driven pumps.

Centrifugal and rotary pumps should be specified as to make, type,

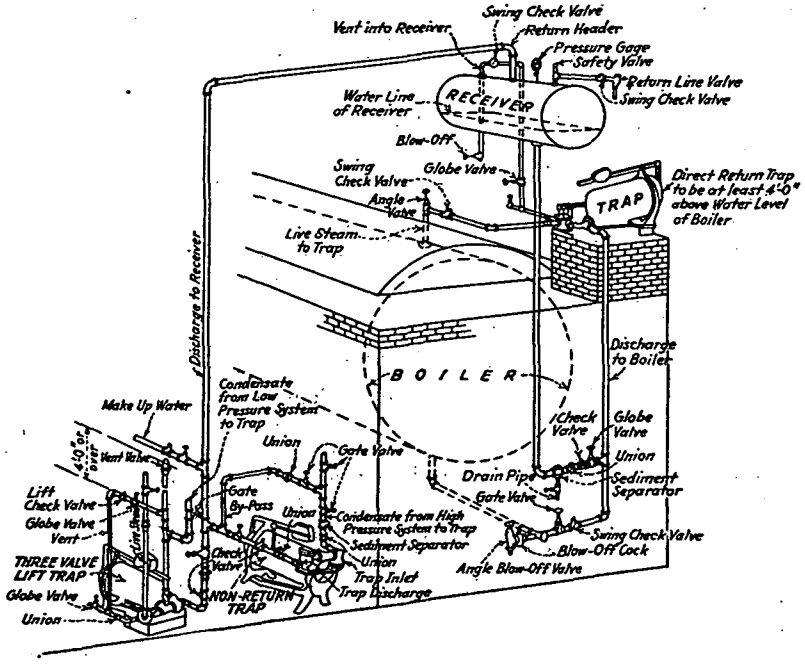


FIG. 9. TRAPS AND RECEIVER FOR RETURNING CONDENSATE FROM HIGH AND LOW PRESSURE SYSTEMS TO A BOILER

capacity, temperature of water to be handled, speed and motor characteristics including the following:

(1) Name of motor manufacturer, (2) manufacturers rated horsepower, (3) the maximum temperature rise (deg. C.) for any part of the motor above the temperature of the surrounding air, (4) full speed in revolutions per minute, (5) current characteristics, (6) whether the motor is to be open, semi-enclosed or fully enclosed, (7) kind of starting and control equipment, i.e., open or enclosed panels, manual or automatic controls.

There should also be included in the specifications such items as total head to be pumped against including suction lift, friction head, velocity

head and head against which the pump must discharge. The vacuum under which return pumps are required to operate and whether two or more units are to operate in parallel or separately.

TYPES OF PUMPS

The following definitions of the types of pumps, which are in accordance with the *Hydraulic Societies' Standards*, should be used:

Direct Acting Steam Pump.—A steam driven reciprocating pump in which the steam piston is directly connected to the liquid piston or plunger through the piston rod.

Crank and Flywheel Pump.—A steam driven reciprocating pump with crankshaft on which a flywheel is mounted for storing energy during the early part of the stroke and imparting this stored energy to the liquid piston or plunger during the latter part of the stroke, after the steam is cut off in the steam cylinder. The length of the stroke is determined by the throw of the main crank.

Single Steam Pump.—A steam driven reciprocating pump having one liquid piston or its equivalent single or double acting plunger.

Duplex Steam Pump.—A steam driven reciprocating pump having two liquid pistons or their equivalent single or double acting plungers.

Power Pump.—A reciprocating pump driven by power from an outside source applied to the crankshaft of the pump.

Single Power Pump.—A power driven reciprocating pump having one liquid piston or its equivalent single or double acting plunger.

Duplex Power Pump.—A power driven reciprocating pump having two liquid pistons or their equivalent single or double acting plungers.

Triplex Power Pump.—A power driven reciprocating pump having three pistons or their equivalent single or double acting plungers.

Single Stage.—A centrifugal pump having one impeller.

Multi-Stage.—A centrifugal pump having two or more impellers acting in series in one casing.

Screw or Propeller Pump.—A centrifugal pump having a screw type impeller. May be axial flow or combined axial and radial flow type.

FITTINGS OF PUMPS

The following definitions of the fittings of pumps, which are in accordance with the *Hydraulic Societies' Standards*, should be used:

Standard Fitted Steam or Power Pumps (*Symbol S. F.*).—Steel piston rods, iron liquid pistons or plungers, bronze or rubber liquid valves, bronze liquid valve seats, guards and springs, liquid cylinders iron or steel. Piston pattern pumps have bronze lined liquid cylinders. Plunger pattern pumps, iron cylinders and plunger glands (not bushed), steel cylinders, and plunger glands (bronze bushed).

Bronze Fitted Steam or Power Pumps (*Symbol B.F.*).—Bronze piston rods (except end packed plunger pattern) iron liquid pistons or plungers, bronze or rubber liquid valves, bronze liquid valve seats, guards and springs, liquid cylinders iron or steel; piston pattern pumps have bronze lined liquid cylinders, plunger pattern pumps have bronze bushed plunger glands and throats.

Full Bronze Fitted Steam or Power Pumps (*Symbol F. B. F.*).—Bronze piston rods (except end packed plunger pattern) bronze liquid pistons or plungers, bronze or rubber liquid valves, bronze liquid valve seats, guards and springs. Liquid cylinders iron or steel. Piston pattern pumps have bronze lined liquid cylinders, plunger pattern pumps have bronze bushed plunger glands and throats.

Acid Resisting Pump (*Symbol A. R.*).—All parts of the pump in direct contact with the liquid pumped are to be constructed of such materials as will offer the maximum resistance to the corrosive action of the liquid.

All Bronze Pump (*Symbol A. B.*).—All parts of the pump coming in direct contact with the liquid pumped are to be made of bronze.

All Iron Pump (*Symbol A. I.*).—All parts of the pump coming in direct contact with the liquid pumped are to be made of iron or ferrous metal.

Standard Fitted Centrifugal Pumps (*Symbol S. F.*).—Casing of cast-iron, shaft of steel, impeller of bronze or cast-iron, wearing rings and shaft sleeves when used of bronze or cast-iron.

Bronze Fitted Centrifugal Pumps (*Symbol B. F.*).—Casing of cast-iron, shaft of steel, impeller of bronze, wearing rings and shaft sleeves when used, of bronze.

STANDARD EQUIPMENT OF PUMPS

The following lists of standard equipment, which are in accordance with the *Hydraulic Societies' Standards*, should be used:

Trade Steam Pumps (*Single or Duplex*).—The following is considered standard equipment for trade pumps and is to be furnished by the manufacturer:

Drip cocks for steam cylinders, Drain plugs for liquid cylinders, Special wrenches, Piston packing for *water* only, Oil or grease cups for rocker shafts, companion flanges for all openings up to 6 in. inclusive.

Plunger packing will be furnished for inside packed plunger pumps. Packing will not be furnished for outside packed plunger pumps.

Power Pumps.—The following is considered standard equipment for duplex and triplex power pumps:

Liquid Valve Service, Oil or Grease Cupers, Tight pulley only, Discharge air chamber up to 400 lb. pressure. Companion flanges up to and including 6 in. Special wrenches where required.

Gear Guard covering the teeth of the pinion and the adjacent teeth of the gear will be furnished as a part of the Standard Equipment. *Gear Guards conforming to the laws of the various states will be furnished as extras, when such laws are quoted in the purchaser's inquiry or order.*

Centrifugal Pumps.—The following is considered standard equipment for horizontal centrifugal pumps:

Coupling or pulley, Bed plates up to 24 in. pumps inclusive, Oil gages for bearings. Air cock at top of pump casing. Drain plug at bottom of pump casing. Packing for shaft stuffing boxes. Water seal gland—piping for same optional. Special wrenches when required.

DEFINITION OF TERMS USED

The following definitions of terms, which are in accordance with the *Hydraulic Societies' Standards*, should be used:

Static Head is the vertical distance between the free level of the source of supply and to the point of free discharge, or to the level of the free surface of the discharge water.

Total dynamic head is the vertical distance between the source of supply and point of discharge when pumping required capacity, plus velocity head, plus friction, velocity, entrance and exit losses.

Total dynamic head as determined on test, where suction lift exists, is the reading of a mercury column connected to the suction nozzle of pump plus the reading of a pressure gage connected to discharge nozzle of pump, plus vertical distance between point of attachment of mercury column and center of gage, plus excess, if any, of velocity head of discharge over velocity head of suction as measured at points where the instruments are attached, plus head of water resting on mercury column, if any.

Total dynamic head as determined on test, where suction head exists, is the reading of a gage attached to the discharge nozzle of pump minus the reading of gage connected to the suction nozzle of pump, plus or minus vertical distance between centers of gages (depending on whether suction gage is below or above discharge gage), plus excess, if any, of velocity head of discharge over velocity head of suction as measured at points where instruments are attached.

Total dynamic discharge head is the total dynamic head minus dynamic suction lift, or plus dynamic suction head.

Suction Lift.—Suction lift exists when the suction measured at the pump nozzle and corrected to the center line of the pump is below atmospheric pressure.

Static suction lift exists when the source of supply is below the center of pump and is the vertical distance from the free level of source of supply to center of pump.

Dynamic suction lift, where static suction lift exists, is the vertical distance from the source of supply, when pumping required capacity, to center of pump, plus velocity head, plus entrance friction and velocity losses, but not including internal pump losses, where static suction head exists but where the losses exceed the static suction head, the dynamic suction lift is the sum of the velocity head, entrance, friction and velocity losses, minus the static suction head, but not including internal pump losses.

Dynamic suction lift as determined on test, is the reading of a mercury column connected to suction nozzle of pump, plus vertical distance between point of attachment of mercury column to center of pump, plus head of water resting on mercury column if any.

Suction Head (sometimes called head on suction) exists when the pressure measured at the suction nozzle and corrected to the center line of the pump is above atmospheric pressure.

Static suction head exists when the source of supply is above the center of pump and is the vertical distance from the free level of the source of supply to center of pump.

Dynamic suction head, where static suction head exists, is the vertical distance from the source of supply, when pumping at required capacity to center of pump, minus velocity head, minus entrance friction and velocity losses, but not minus internal pump losses.

Dynamic suction head as determined on test is the reading of a gage connected to suction nozzle of pump, minus vertical distance from center of gage to center line of pump. Suction head, after deducting the various losses, may be a negative quantity, in which case a condition equivalent to suction lift will prevail.

Guarantee on Suction Lift.—All guarantees unless otherwise specified should be based on handling clear fresh water at a temperature of not over 85 deg. fahr. and a total dynamic suction lift of not over 15 ft. at sea level.

HORSE POWER OF MOTORS

For motors of less than 100 hp. capacity when rated on a 50 deg. basis and when used to drive centrifugal pumps should be of a capacity at least 20 per cent above the actual horsepower required by the pump. When rated on a 40 deg. basis the extra margin of capacity should be made 5 per cent in excess of the actual power required by the pump at the normal rated capacity conditions for which the pump is guaranteed. For motors over 100 hp. capacity the rated motor capacity may be less than that given previously.

INSTALLATION DATA

All pumps, in general, should be set on substantial foundations and be provided with heavy cast iron sub-bases, securely anchored to foundation and provided with drip rim with drain connected to sump or sewer.

Especially in the case of centrifugal or turbine pumps every reasonable precaution should be taken to prevent distortion of base plates of pumps due to handling in shipment or bolting down without suitable grouting.

Flexible couplings should not be used to compensate for misalignment but only to compensate for temperature variations.

Pipe connections should, in general, be supported to prevent undue stresses in pumps due either to weight or expansion.

The exhaust from steam driven pumps supplying steam for heating purposes should be taken through an effective oil separator before entering any part of the heating system or other apparatus.

A full set of the manufacturers working drawings should be used in connection with each installation.

TRAPS

Traps ordinarily used in connection with heating and ventilating engineering may be divided into the following three types: (1) steam traps, (2) oil traps, (3) air traps.

Steam traps may be sub-divided into: (*a*) high-pressure steam traps, (*b*) low-pressure steam traps, and each of these two sub-divisions may be further sub-divided into: (1) float traps, (2) bucket traps, (3) thermostatic traps, (4) return traps, (5) lifting traps, (6) alternating receiver traps, (7) tilt traps.

The fundamental principle upon which the operation of practically all traps depend is that the pressure within the trap at the time of discharge, shall be equal to, or slightly in excess of, the pressure against which the trap must discharge, including the friction head, velocity head and static head on the discharge side of the trap. If the static head is in favor of the trap discharge it is a minus quantity and may be deducted from the other factors of the discharge head.

The capacity of a trap depends upon the clear area through its discharge ports and the difference between the pressure within the trap and the total pressure against its discharge, at the time of discharge.

The opening of the ports of a trap may be a very variable quantity, depending upon the action of the mechanism in opening and closing the valves.

Float traps and thermostatic traps generally have gradual opening and closing of valves, although some of these are arranged with levers, weights, springs, etc., so as to snap open and close, thus giving a full opening of the valves and ports during the entire time of each discharge.

Bucket traps, tilt traps and alternating receiver traps have quick acting valves and therefore wide open ports during each discharge.

Uses of traps in connection with heating and ventilating apparatus are for; draining the condensate from all kinds of radiators, heaters, steam piping systems, kitchen equipment, laundry equipment, hospital equipment, drying equipment and many other kinds of steam heated apparatus. The usual function of a trap is to allow the passage of condensate and to prevent the passage of steam. In addition to these functions, traps are frequently required to allow the passage of air as well as condensate. Traps are also required to allow the passage of air and to prevent the passage of either water or steam, or both.

In addition traps are used for returning condensate either by gravity, by steam pressure, or by both to a boiler or other point of disposal. Also for lifting condensate from a lower to a higher elevation, or for handling condensate from a lower to a higher pressure.

By-passes are usually provided around traps with a valve and union on each side of the trap and one of each in the by-pass. Some traps are provided with integral by-passes for temporary relief in case of emergency, but these do not allow the removal of the trap for repairs without interrupting the service.

High-pressure float, and alternating traps are usually provided with glass water gages, drain cocks and air relief cocks or automatic air relief valves.

Tilt traps are not ordinarily equipped with glass water gages as the action of the trap shows when it is filling or emptying.

The air relief of tilt traps is taken care of by the valves of the trap. High-pressure traps for handling large volumes of condensate are usually

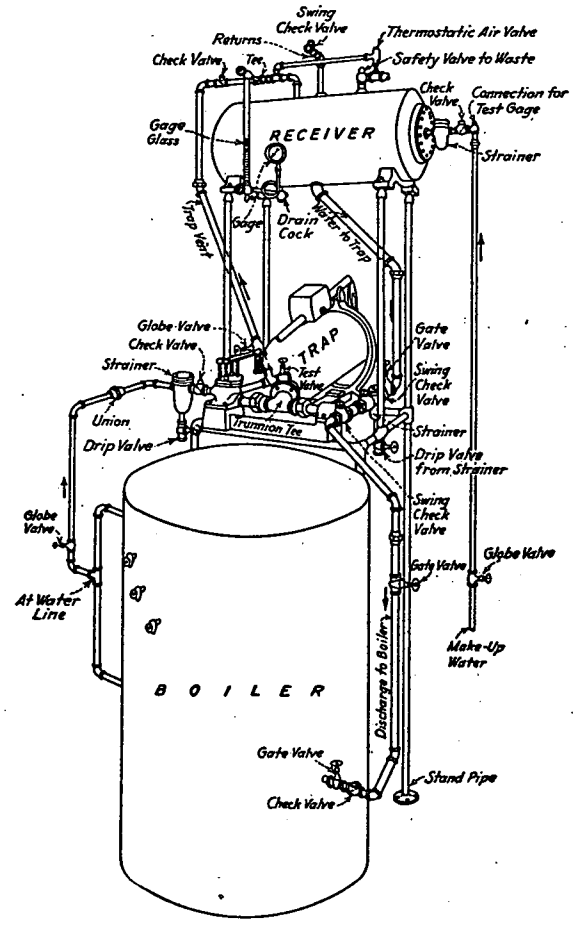


FIG. 10. RETURN TRAP AND RECEIVER FOR AUTOMATIC BOILER FEED

of the float, bucket, tilt or alternating types, although some forms of thermostatic traps are designed for this kind of service. For smaller high-pressure apparatus many types of thermostatic traps are very efficacious. Care should be taken to see that thermostatic traps of the bellows or diaphram type, when used for high-pressure service are

properly constructed with materials and solder that will properly withstand the maximum temperature of the steam.

Low-pressure traps of the various types are equipped substantially the same as high-pressure traps of similar types. Thermostatic traps are generally used for draining radiators and heaters except for very large capacities where bucket, float or blast traps are used. Thermostatic traps for this service usually pass both condensate and air and in case of float and bucket traps the air is usually relieved through an auxiliary thermostatic trap in a by-pass around the main trap. Sometimes this auxiliary air trap is an integral part of the trap. Blast traps are sometimes used on a vacuum heating system for connecting old one or two-pipe gravity systems in parallel with vacuum return line systems; in which case the blast traps should not be provided with auxiliary air by-pass, as the action of this will allow the vacuum to draw air into the old system through its air valves, especially when the steam is wholly or partially cut off. The air from the returns of such old systems should be relieved just ahead of the blast traps by means of quick venting automatic air valves, preferably of the non-return type, especially if the other air valves on the old system are non-return valves.

Lifting traps will discharge from a lower to a higher pressure and are usually of the tilt or alternating type. Either of the two former types of traps are provided with two or three valves, operated by the action of the trap.

In case of the two-valve traps, one valve closes a steam inlet and the other valve opens a vent outlet while the trap is filling and as soon as the trap dumps the first valve opens the steam inlet and the second valve closes the vent outlet, while the trap discharges. In this type of trap there must be a swinging check valve on each side of the trap, in addition to the usual by-pass, to prevent the pressure in the trap, while discharging, from backing up through the inlet and the pressure in the discharge line from backing up into the trap while it is filling. This type of trap will blow steam out through the vent while filling, if the pressure on the inlet side is sufficient, and should not be used, therefore, with such pressures unless the vent is properly piped back into the return to a feed water heater, condenser or to a perforated pipe in the bottom of the receiver to which the trap discharges, in such a way as to prevent the escape of the steam that comes in with the condensate and passes through the vent. In the three-valve traps of this type there is an extra valve for closing the discharge while the trap is filling.

Some tilting traps are designed for use without venting any steam but with automatic thermostatic air trap for venting the air. Some of these are equipped with automatic valves for introducing a water spray while the trap is filling thus condensing the steam, not only from the former discharge but from the intake and re-evaporation. Such may be used as vacuum traps for producing pressures below atmosphere on the system to which the trap is connected.

Fig. 9 shows a lifting trap, a receiver and a return trap connected for lifting condensate from a system of returns and returning same to a boiler. The venting and condensing arrangements referred to above are also shown.

Fig. 10 shows a direct return trap and receiver properly connected for automatically feeding a boiler from a system of returns delivering the condensate to the receiver.

Oil traps are used for draining the oil and condensate from oil separators, muffler tanks, etc., and are usually of the float type.

Air traps are used for relieving the air from steam heating systems, hot-water heating systems, domestic hot-water systems, etc. For steam heating systems where air and water are to be passed and steam retained they are of the thermostatic type. Where air is to be passed and steam

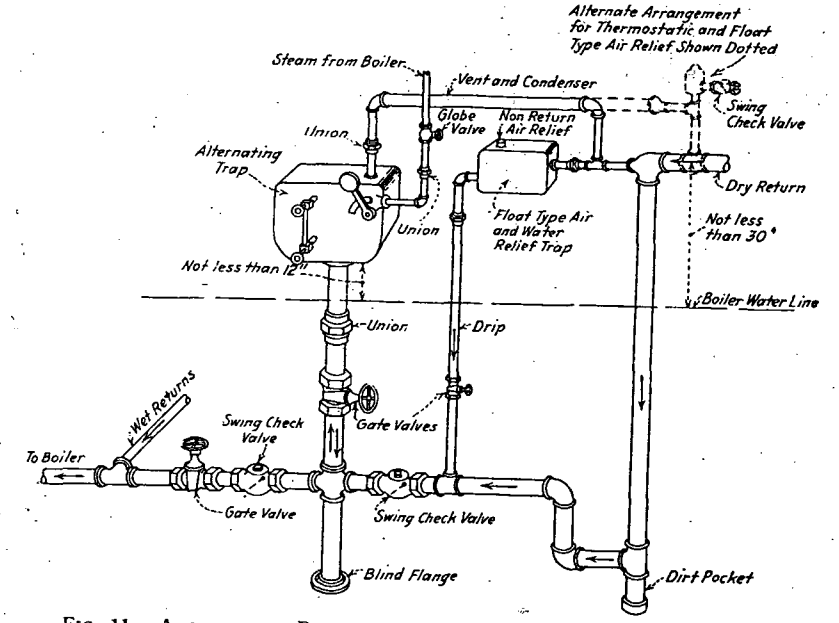


FIG. 11. ALTERNATING RECEIVER ON LOW PRESSURE HEATING RETURNS

and water retained they are of the combination thermostatic and float type. For water systems where air is to be passed and water retained they are of the float type.

Alternating receiver type traps are used for returning the condensate to boilers or for lifting condensate from a lower to a higher level. They are generally of the two-valve type with one valve in the steam supply and one valve in the vent. The action of the float opens the vent and closes the steam supply while the trap is filling by gravity and closes the vent and opens the steam supply while the trap is discharging. The steam from the vent may be connected back into the return system to the trap to prevent the waste of heat. This type of trap requires a swinging check on each side to prevent the backing up of the discharge from the return system while the trap is discharging or into the trap while

it is filling. The air is vented from the system, either through the vent of the trap to the atmosphere, or where this vent is connected back into the returns the air is vented separately from the trap vent through a thermostatic air trap.

Fig. 11 shows an alternating receiver properly connected for returning the condensate from a low-pressure heating system to the boiler. The trap vent in this case is connected back into the returns with a thermostatic air trap for relieving the air. In this arrangement a check valve on the air vent prevents the return of air to the system during periods when the pressure in the system is below atmospheric pressure. With this arrangement or with some other special types of non-return air venting apparatus the system may be operated over long periods below atmospheric pressure, thus retaining heat over night or during warm weather with a low fire and nothing more than a vapor in the system. The pressure must eventually be raised above atmosphere, however, at certain times to drive out the air, which eventually leaks into even the tightest system, while operating below atmospheric pressure.

CHAPTER XIX

LAUNDRY, KITCHEN AND HOSPITAL EQUIPMENT AND PIPING SYSTEMS

Types, Kinds and Sizes of Apparatus Required, Steam and Hot Water Requirements; Electric Requirements, Layouts, Installation Data.

THE requirements of laundry, kitchen and hospital equipment vary over wide limits, because, *first*—there are so many different classes of laundries, kitchens and hospitals, *second*—the operating technique varies so much. The data and methods herein given are for average operating conditions, but unusual requirements should be given special consideration.

Piping systems for laundry, kitchen and hospital equipment, generally, should have separate flow and return lines either above or below the equipment but it is better to have the return lines below.

Traps (preferably high-pressure thermostatic) are placed on each coil or unit, and the condensation is trapped into a return main which is itself vented, and leads by gravity to a vented receiving tank or feed water heater.

The vertical pipe in connections, especially the drop lines from overhead mains may be dripped through separate traps, although these may well be omitted as the fixture coils and traps will care for a limited amount of condensation when the fixture valves are opened up, without damage.

The steam mains should be dripped and drained in about the same manner that would be required in steam piping for any other purpose.

LAUNDRY EQUIPMENT

It is not the purpose to include custom laundries here but rather flat work laundries for hospitals, institutions, hotels, etc.

There is a wide variety of special machines, used mostly in custom or general laundries, that will not be mentioned herein. Some of these machines are occasionally used in flat work laundries where a limited amount of other classes of work is to be done but usually they occupy little floor space, use small amounts of steam, water and electricity and when their need is felt they can be added without materially effecting the layout of the other and larger machines which require much floor space and use considerable quantities of steam, water and electricity.

These larger machines are washing machines, extractors, tumbler dryers, flat work ironers and similar units.

The material for this Chapter was prepared especially for THE GUIDE by a committee consisting of H. C. Russell, *chairman*; E. E. Ashley, R. C. Taggart and W. B. Underwood.

Proportioning Equipment

Probably the minimum equipment of a well equipped flat work laundry, outside of the capacity of a domestic laundry, is as follows: one, 36 in. x 48 in. washing machine; one, 36 x 64 in. washing machine; one, 26 in. centrifugal extractor; one, 4-roll 90 in. flat work ironer; one, 30 x 42 in. drying tumbler; one, 2-truck dry room; one, 15 gal. starch cooker; one, 38 in. pressing machine for uniforms, etc.; one, hand ironing board, two 8 lb. electric irons; two, laundry tubs and one wringer.

If it is a hospital laundry, one disinfector about 36 in. high x 42 in. wide x 84 in. long may be included. This is large enough to receive an ordinary hospital mattress without distortion. It is placed in the laundry, rather than elsewhere, for the reason that its principal work consists of disinfecting (or sterilizing) clothes and other things to be laundered.

Such a laundry would meet the requirements of a 250 bed hospital or a 350 room hotel on a basis of 44 hours operation per week. For a smaller number the equipment would be about the same but it would be operated fewer hours per week. The purpose of the two washing machines in the minimum laundry is primarily to provide a breakdown service. Washing machines require repairs oftener than any other machine in the laundry and they are indispensable to the operation of the plant. One small washing machine is generally desirable in any plant, however large the number of washing machines.

Typical Layout

Fig. 1 illustrates a layout of a laundry for a 500 bed hospital, the equipment consisting of:

One, 36 in. high x 48 in. wide x 84 in. long disinfector; one, 36 in. x 48 in. standard washing machine; two, 42 in. x 72 in. standard washing machines; one, 60 gal. soap tanks; one, 48 in. and one, 30 in. extractor, one, 42 in. x 90 in. drying tumbler; one, 120 in. six-roll flat work ironer; two, 38 in. garment presses; two, 49 in. garment presses; one, 66 in. handy flat work ironer; one set of hose forms; five hand ironing boards; six, 8 lb. electric irons; one, 20 gal. starch cooker; one, 36 in. x 60 in. starch table; two laundry trays; two wringers attached to trays; two, 36 in. x 120 in. wood tables for flat work ironing; four, 24 in. x 24 in. x 30 in. truck tubs; one, electric sewing machine.

Washing Machines

In the instances cited the washing machines are of the standard type, in which about one cycle, or washing, per hour is accomplished. There is another type of so-called *high duty* washer in which, on account of larger supply and waste connections, approximately two cycles per hour are possible if the attendants will work fast enough, with consequent doubling of capacity.

Another type is called a sterilizing washing machine and is specially designed for hospital use. The bodies are steam tight and operate with a pressure of about 30 lb. while washing. Laundry from the average hospital is not disinfected, even though much, if not all of it, might better be.

With average material about 2 lb. of dry laundry per cubic foot cylinder

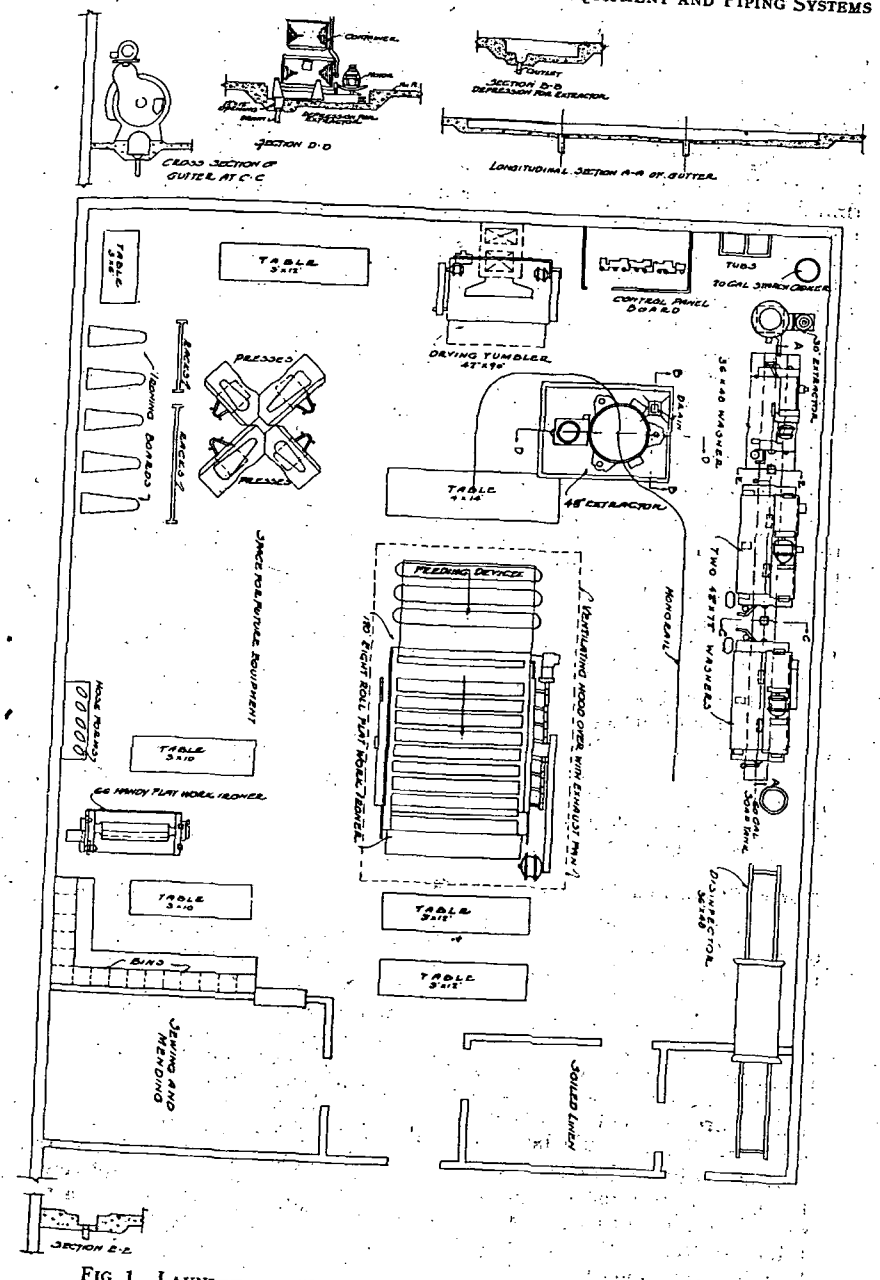


Fig. 1. Laundry for 500 Bed Hospital (Floor Area 4600 sq. ft.)

capacity, of standard machine and twice this amount for high duty machines, may be figured per hour.

Flat Work Ironers

The capacity of flat work ironers depends upon width of machine, number of rolls, steam pressure carried and efficiency of venting and draining steam and air. The proportions given in the cases cited give a good index as to the number of machines required. Probably it is not advisable to install flat work ironers with less than five rolls, especially when blankets are to be laundered, which is usually the case in a flat work laundry. With a lesser number of rolls too much material has to be run through twice or more. In most cases a six-roll flat work ironer is preferable. Care must be taken to see that the length of the rolls is well above the width of the widest sheets, etc. to be ironed.

Flat work ironers are rated on length of roll in inches and number of heated rolls. Thus a 110 in. five-roll machine has five heated rolls each 110 in. long.

Tumbler Dryers

The proportion of tumbler dryer capacity to washers is established in the instance previously mentioned. For an unusually large proportion of blankets and similar articles, larger tumbler dryers would be required, and in a locality where no blankets were used they may be reduced.

Tumbler dryers are simply high duty dryers for work that could be done in the dry rooms. It is not an absolutely necessary machine, but is practically so regarded today.

Tumbler dryers are rated on diameter and length of the cylinder for the reception of material to be dried. A 42 in. x 72 in. drying tumbler has cylinder 42 in. diameter x 72 in. long.

Each of these machines is provided with a small hot-air fan as part of the machine. Provisions should be made for a duct from air outlet to discharge out-of-doors, as the lint and humid air carried is objectionable when discharged into the rooms.

Water, Steam and Power Requirements

The minimum water, steam and power requirements are about 100 gal. of cold water, 80 gal. of hot water, 30 lb. of steam and 1 k.w. of electricity per 100 lb. of clothes (dry). The average laundry will exceed these by 50 per cent and small laundries by 100 per cent.

The instantaneous demands for steam and water are much higher than the average. Due to the heavy instantaneous demands, especially in a small laundry, it is well to supply the laundry from the main boiler plant, where these drafts will be least felt. In this case the amounts given in Table 1 are satisfactory for a medium size flat work laundry, with standard washers. They should be doubled if high duty washers are used.

If an individual boiler is installed for the laundry, or for other reason the load curve must be flattened out, the use of larger tanks and consequently more storage is necessary. Tanks double the sizes given in this table are frequently required. In estimating the hot water demand the laundry trays may ordinarily be neglected.

Table 1. Water Requirements of Standard Washers

Size of Washing Machine	Gallons Hot Water per Hour per Washer	Capacity in Storage Tank per Washer
Small	150	100
Medium	200	150
Large	300	200

The average drying tumbler, say 42 in. x 72 in. requires about 600 lb. of steam per hour. Steam requirements of other machines and dry room combined do not exceed one third that of the drying tumbler. Washing machines have steam connections and sometimes considerable steam is used there, but this is reflected in the reduced amount of hot water used. In some cases steam is liable to carry oil in suspension and its use in washing machines is objectionable so provision for its elimination should be made.

The maximum demand for electric feeders should be taken at full connected load for direct current, and for alternating current the power to operate the largest washing machine should be added to the full connected load. The reason for the latter requirement is to provide for reversal of machines which is negligible with direct current but considerable for alternating current.

Washing machines require from 2 to 8 hp. for drive according to size, plus 100 per cent for reversing when alternating-current machines are used. Extractors require 2 to 5 hp. to drive, according to size. Tumbler dryers require 3 to 6 hp. to drive, according to size. Flat work ironers from ¾ to 2 hp. according to size. Electric irons require from 500 to 1000 watts, according to size.

Steam Pressure Required

The capacity required of the flat work ironer largely fixes the steam pressure required as all other machines may use steam at widely varying pressures without appreciably effecting their operation or capacity.

With a flat work ironer of five or six rolls and of ample capacity 70 lb. per square inch is generally sufficient but pressures of 90 lb. are not uncommon in order to get the capacity out of the machine. Occasionally the work on such a machine is so light that 50 lb. is sufficient.

Sixty pounds are ample for the disinfector and small presses used for miscellaneous pressing work.

Pipe Sizes and Systems of Piping

The branches to each machine must be large enough to meet instantaneous requirements but the steam and water mains need not exceed one half the combined area of the branches, as it is unlikely that more than two heavy machines will be drawing full capacity simultaneously.

Steam connections to washing machines are ¾ in. to 1 in. according to size; tumbler dryers, 1 in. to 1¼ in. according to size; dry rooms generally ¾ in.; flat work ironers, ¾ in. to 1 in. according to size; to starch cookers ½ in. and to garment presses and miscellaneous small machines ½ in. There are several small connections to the disinfector, but main supply should be 1 in.

A ½ in. return connection and ½ in. thermostatic trap is ample for any coil or heating unit except ironers and tumblers which should be ¾ in. return with ¾ in. thermostatic trap. Return mains having an area one half the combined area of the branches is ample, ¾ in. being the minimum pipe size.

Occasionally it may be necessary to run return mains at the laundry ceiling, but this should be avoided if possible. In such cases mechanical traps instead of thermostatic traps are used, the condensation being lifted from floor to the return by the pressure of the steam.

Cold water and hot water connections to washing machines are 1½ in. to 2 in. according to size; ½ in. to soap tank and starch cooker and ¾ in. to each laundry tray. These are sufficiently large with water pressures ordinarily found.

The so-called *high duty* washing machines usually have two connections each same size as for standard washers of corresponding size. Quick filling is a necessary requirement to secure the extra capacity claimed for these machines.

Water Softening

Fairly soft water, the softer the better, is an absolute necessity if a clean white wash is to result. With hard water the soap forms insoluble compounds with calcium, magnesium and iron which cling to the washed fibres and after they have been through the flat work ironer the spots turn various colors. In addition to this more soap is required with hard waters than with soft, the excess depending upon the amount of hardness present. Before any lather is formed the soap must neutralize the hardness of the water. One pound of average soap will soften (bring to point of producing lather) 167 gal. of water when the hardness is 20 parts per million, but only 40 gal. when the hardness is 100 parts per million. Seventeen parts per million is equivalent to one grain of hardness, by weight, per gallon.

From 15 to 25 per cent more water is used when it is very soft than when it is very hard for the reason that in rinsing, the hard water immediately precipitates the excess soap used in the washing process.

Arrangement of Equipment

For efficient operation the arrangement of equipment must be given careful study so that it will fit in with the natural sequence of operations from receiving to delivery. Any backward movement of material that might involve possible contact of washed materials with unwashed material must be guarded against.

Whenever possible the laundry should be a separate building. The ceilings of the building should be high and the rooms well ventilated by large windows and adequate roof ventilators. Ventilating fans will frequently be required.

All operations except receiving, mending, storing and delivery should be carried on in one room.

KITCHEN EQUIPMENT

The equipment covered herein includes the usual cooking equipment found in the ordinary institution or hotel kitchen. There are other

special appliances found in all kitchens, but for the most part such appliances require small space, nominal amounts of steam and in many cases none at all. They are frequently added and may be placed in any properly designed kitchen with little or no disturbance to existing equipment.

Character of Equipment

Nearly all *steam* kitchen equipment such as steam tables, dishwashing machines, warmers, kettles, etc., can be obtained either for gas or steam heat.

For a small kitchen, where gas is available, and a separate steam boiler would be required for the kitchen, it is probably better to use the direct gas-fired equipment. If the kitchen is large it is better to install the usual steam equipment even if a separate steam boiler is required.

Steam heated equipment has certain inherent advantages over gas for steam tables, dishwashers, kettles, etc. It is more nearly fool-proof and steam can be left on a dry fixture indefinitely without damage but not so with gas. The upkeep and maintenance cost of steam equipment is less than with gas equipment and the fuel costs are generally less, even with a gas-fired steam boiler.

The range may be fired with wood, coal, oil or gas, preference being given to the latter. Electricity will be considered as always available for power purposes and for small hot-plates, broilers, etc. The use of electricity for the range is practicable, and for that matter ideal, but too expensive except in isolated cases.

Proportioning Equipment

It is difficult to lay down general rules for proportioning equipment. So much depends upon the technique employed by the management and the partial preparation of food at points other than in the main kitchen. The proportions laid down here are subject to wide variation to meet requirements for a specific case. They are based on steam heated equipment but no substantial difference in capacity exists if gas heated equipment is used.

Ranges

The smallest practicable gas or coal range has a top surface of about 7½ sq. ft. and an oven volume of about 4000 cu. in., which is sufficient for about 25 persons on the theory that no kettles, roasting ovens, etc., would be installed in such a small kitchen, and that all such cooking would be done on the range. About 15 sq. ft. top surface and 8000 cu. in. oven space is good for 100 persons. For each additional 100 persons allow about 7½ sq. ft. top surface and 4000 cu. in. oven space.

A steel hood with a good draft is required over the range and generally a fan is used to produce sufficient dependable draft. The range generally stands against a wall and the hood should project 12 in. or more beyond the edge of the range at ends and front. The best type of hood is a double hood as shown in Fig. 2. The slot is 2 in. wide and is the full periphery of the hood on front and sides. The volume of air should be sufficient to

produce a velocity of 900 ft. per minute through the slot, or about 150 cu. ft. air per minute per linear foot of slot.

Cook's Table

The cook's table is about 3 ft. wide, practically the full length of the range and is generally placed opposite the range front and about 4 ft. 6 in. from it. Cook's tables frequently contain warming closets underneath and steam tables on top.

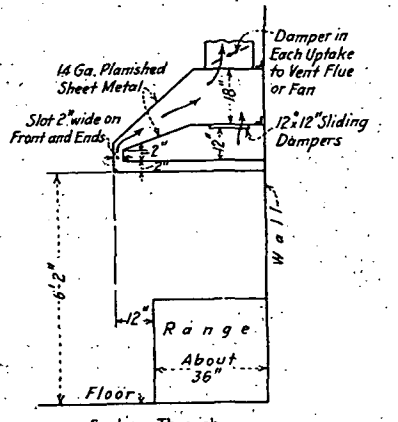


FIG. 2. DETAILS OF RANGE HOOD

The "bain marie" is generally built in a part of the cook's table or installed at one end of the table. A cook's sink, which is a simple galvanized sink without back, size about 18 in. x 36 in. x 6 in. deep is often placed at the end of the cook's table opposite the "bain marie."

The saucepan rack is almost invariably the full length of the cook's table and consists of two rails or racks about 24 in. apart, one rail over each edge of the table, with semi-circular connecting rail at each end. Hooks are attached to the rails upon which pans and kettles are stored. In small units they are often supported by standards attached to the table but in larger sizes they are supported from the ceiling, leaving the table free of such obstructions.

Kettles, Ovens and Steamers

Stock kettles, roasting ovens, vegetable steamers, cereal cookers, are not often installed in kitchens to serve less than 50 persons, such cooking being done on the range.

The following sizes of steam kettles and roasting ovens are suggested:

One, 25 or 30 gal. kettle and one, 25 or 30 gal. roaster will serve 250 to 300 persons; one, 40 or 50 gal. kettle and one, 40 or 50 gal. roaster will serve 350 to 450 persons; two, 30 or 40 gal. kettles and two, 30 or 40 gal. roasters will serve 500 to 700 persons; three, 30 or 40 gal. kettles and three, 30 or 40 gal. roasters will serve 750 to 1000 persons;

To put it in another way the requirements of hotel kitchens where steam kettles alone are used are given as follows:

100 rooms, one, 40 gal.
250 rooms, one, 50 gal., one, 25 gal., and one 10 gal. without cover.
500 rooms, one, 75 gal., three, 60 gal., and one, 20 gal. without cover.
800 rooms, two, 100 gal., two, 75 gal., one, 60 gal., one, 40 gal., and one, 25 gal. without cover.
1000 rooms, four, 100 gal., three 80 gal., one, 60 gal., one, 25 gal., one, 25 gal., tilting type, and one 60 gal. without cover.

A hospital or institution kitchen where the staff dining hall and diet kitchens are served by the main kitchen should be equipped about as follows:

For 50 beds, one, 25 gal.; 150 beds, one, 25 gal. and one 40 gal.
250 beds, two, 60 gal. and one, 10 gal. without cover.

Vegetable steamers are not usually installed for less than 50 persons, such cooking being done on other equipment. A two bushel steamer will serve 200 persons and an additional two bushel steamer for each 200 persons until three such steamers are installed which is sufficient for 1000 persons. Vegetable steamers are made in one, two and four bushel sizes.

The compartment type of cast-iron vegetable steamers are not largely used now. They are difficult to keep clean, leak between the sections and the doors are hard to keep tight.

Cereal Cookers

One, 15 gal. cereal cooker will serve 100 persons and an additional one of the same size is needed for each 200 persons additional until four such cookers are installed which is sufficient for 1000 persons.

Coffee Urns

A pair of coffee urns, each having a capacity of 5 gal. per 100 persons, should be provided; urns having capacity of 3 gal. each being the minimum size to be installed. Coffee urn stands are fitted with a water boiler between the urns having a capacity equal to the combined capacity of the two urns. Generally the urn stand should contain cup warming cabinet below, heated with steam coil or gas.

Steam Tables

In cafeteria kitchens (not cafeteria dining rooms) the steam tables are usually placed opposite the ranges and stock kettles, and largely take the place of the cook's tables hereinbefore referred to.

The following data is given to approximate the size of steam tables:

A 5 ft. 0 in. long unit with two meats, four pots and two gravies will serve 100 to 250 persons; a 6 ft. 0 in. long unit with two meats, four pots and two gravies will serve 150 to 300 persons; a 7 ft. 0 in. long unit with three meats, six pots and two gravies will serve 350 to 500 persons.

One or more of the above sizes are to be installed according to number to be served from steam tables.

Sinks

Pot sinks, work sinks, vegetable sinks, meat sinks are made of galvanized sheet iron, with back 12 in. high and where space permits with integral drain boards on each end.

One 36 in. x 26 in. x 16 in. deep, two compartment, pot sink will suffice for 50 persons and for larger kitchens one such sink 72 in. long, 27 in. wide and 16 in. deep in three compartments should be provided. Only a very large kitchen would require more than one pot sink.

One vegetable sink same size as pot sink should be provided in the vegetable preparation room, and a sink of same size in the general work room.

Smaller sinks, generally 30 in. long by 18 in. wide by 6 in. deep will be required in the salad preparation room, meat cutting department, general serving counter, dessert preparation room and adjacent to the fish refrigerator unless the sink for meat room is available for the latter use.

Fish Refrigerator

Fish cannot be kept in an ordinary refrigerator but may best be kept packed in ice. Up to 100 persons capacity, some make-shift may be depended upon unless fish are to be used extensively, but for larger kitchens a fish-box should be provided. The smallest has an internal capacity of about 9 cu. ft. and is sufficient for 200 persons. The installation of the larger sizes would depend upon whether fish are to be bought daily or kept for longer periods.

Ice Cream and Sherbets

If ice cream is to be made a 20 qt. motor driven freezer should be provided for less than 200 persons. For more than 200 persons a 40 qt. freezer will generally suffice. Ordinarily cracked ice is used, but for large institutions having a central refrigerating plant the use of a brine cooled freezer should be considered. In such cases the refrigerators are usually available for the storage of the cream until used. An ice-breaking machine should be considered.

Requirements for serving cabinets will vary considerably. It should never be less than the capacity of the freezer, however. One 20 qt. can will serve 200 portions.

Ice Chests

An ice chest is required in the kitchen or in connection with it; a 22 in. x 28 in. x 33 in. long is a convenient size.

Mixing Machine

A mixing machine for batters, salad dressings, is generally installed for kitchens serving over 50 persons and occasionally for smaller ones. The 15 qt. size is sufficient only for the smallest kitchens, especially if it must be used for baking mixtures. The 60 or 80 qt. size should be provided for larger kitchens, the 60 qt. size having a capacity great enough for 300 persons.

Vegetable Peelers

Vegetable peeler, or paring machine, should be provided in the vegetable preparation room. The 25 lb. size is sufficient for 100 persons, 40 lb. for 500 persons and the 60 lb. size for 1000 persons.

It is advisable, but not an absolute necessity, to install a small sink with a 3 in. waste outlet, adjacent to this machine, with cold water faucet over it, to take care of the waste. The hopper must be installed close to

the floor, which will generally require the trap to be placed at the ceiling below.

Dish Washing Machines

Dish washing machines are rated in dishes per hour and frequently rated well beyond capacities obtainable under ordinary conditions. The rated capacity of the machine should be ten times the number of meals to be served in any hour.

Such machines are built with one, two and three tanks and a like number of separate sprays. The object of the two or three tank machines is to avoid mixing the wash and rinse waters. The single tank machines are generally made only in small sizes and are suitable for diet kitchens and similar small kitchens only. In the two tank machines the wash and rinse water is separate and in the three tank machines there are two rinse waters.

Certain types of dish washing machines, of the three tank style are semi-sterilizing in their operations in that the last spray, through which the dishes pass, is a mixture of hot water and steam. This type should be installed in hospital kitchens but may be unnecessary in other kitchens. In the ordinary, non-sterilizing type steam connections are required also but steam is used only for heating the water or keeping it hot.

A dishwashing sink, say 30 in. long x 18 in. wide x 6 in. deep with wood drain board at each end, should be provided somewhere near the outlet end of the dishwasher. For one cause or another a dish frequently passes through the average machine without getting properly washed, and must be picked up as it passes out.

Sterilizing dish washing machines and possibly some others, discharge the dishes sufficiently hot to dry themselves almost instantly but not all machines by any means will do this and in such cases dishes must be dried by hand.

Broiler

A broiler may or may not be required in an institution kitchen but is always necessary in a hospital, hotel, club and similar kitchen if more than 100 persons are to be served.

They are obtainable for electric, charcoal or gas heat and in widths 18 in. to 40 in. They are approximately the same depth as ranges and are usually placed at one end of the range so that the range hood can be utilized to carry away the odors.

Miscellaneous

Meat blocks, meat slicers, coffee mill, bread slicers, are necessary and a barrel truck is frequently advisable for a large kitchen or in the bake shop.

Short Order Kitchens

Short order kitchens are sometimes required in hospital kitchens for the preparation of eggs, bacon, toast, etc., which must be served very quickly, and prepared on special order. Such kitchens require equipment of certain variety but of nominal capacity. For the ordinary size hospital 24 in. x 30 in. gas or electric hot-plate, a small steam heated warming closet, an 18 in. x 30 in. x 6 in. deep sink and a small work table would serve.

Diet Kitchens

In connection with hospital kitchens, diet kitchens distributed among the wards and bed rooms are invariably provided. The main dining rooms are built adjacent to the main kitchen and in some cases the so-called "ambulant" patients, and personnel, go to these dining rooms. The diet kitchens are for those confined to beds or rooms.

The bulk of the preparation is performed in the main kitchen and carried to the diet kitchens in heated food carts.

A diet kitchen equipment usually consists of an 18 in. x 24 in. gas or electric hot-plate; one, 4 ft. long steam table with meat pan, four vegetable jars and two gravies; a warming closet below the steam table, a 1500 piece capacity dish washing machine, a small refrigerator and an 18 in. x 30 in. x 6 in. deep sink.

BAKE SHOPS

Baking of bread and pastry if done on the premises should be separated from the main kitchen but adjacent thereto unless there are good reasons for another location. In a contagious hospital, for instance, where the main kitchen may be subject to infection the bake shop would probably do baking for the entire hospital and should be well away from possible infection.

Oven

The capacity of the oven at one baking, which is the method of rating ovens, should be about one half of a pound loaf per person. In large institutions it may be smaller relative capacity and based on more continuous baking operations.

Pastry Oven

A pastry oven having an aggregate baking surface of about 5 sq. ft. per 100 persons should be provided in the bakery. Not infrequently pastry only is baked on the premises and bread is purchased, in which case the separate bake shop can be dispensed with and the pastry oven installed in the main kitchen.

Fuel

If gas is not available it may be advisable to use electric baking and pastry ovens. Ovens fired by coal or wood are often used but are not satisfactory. In general electric cooking is expensive, but of all cooking equipment the bake oven and pastry ovens are the pieces which are best adapted to electric heating.

In addition to the ovens, a properly equipped bakery should contain the following:

One bakery combination consisting of flour hopper, sifter, elevator, tempering tank and dough and cake mixer; having a capacity of ½ bbl. per 100 persons; one steam or gas heated proofing box having a capacity of 12 sq. ft. of shelf per 100 persons; a dough trough from 4 ft. to 10 ft. long with table over; a pair of 400 lb. platform scales; a baker's stove, baker's table, pan racks, bread storage cabinet and a baker's sink.

CAFETERIA RESTAURANT SERVICE

Cafeteria restaurant service, by which persons serve themselves, is frequently provided in institutions and elsewhere. In such cases the

coffee urns, milk urns, ice cream cabinets, heretofore referred to are placed behind the cafeteria rail. In addition to this, provision must be made for steam tables and cold pans for salads, etc. The smaller the relative capacity, of course, the oftener supplies must be replenished.

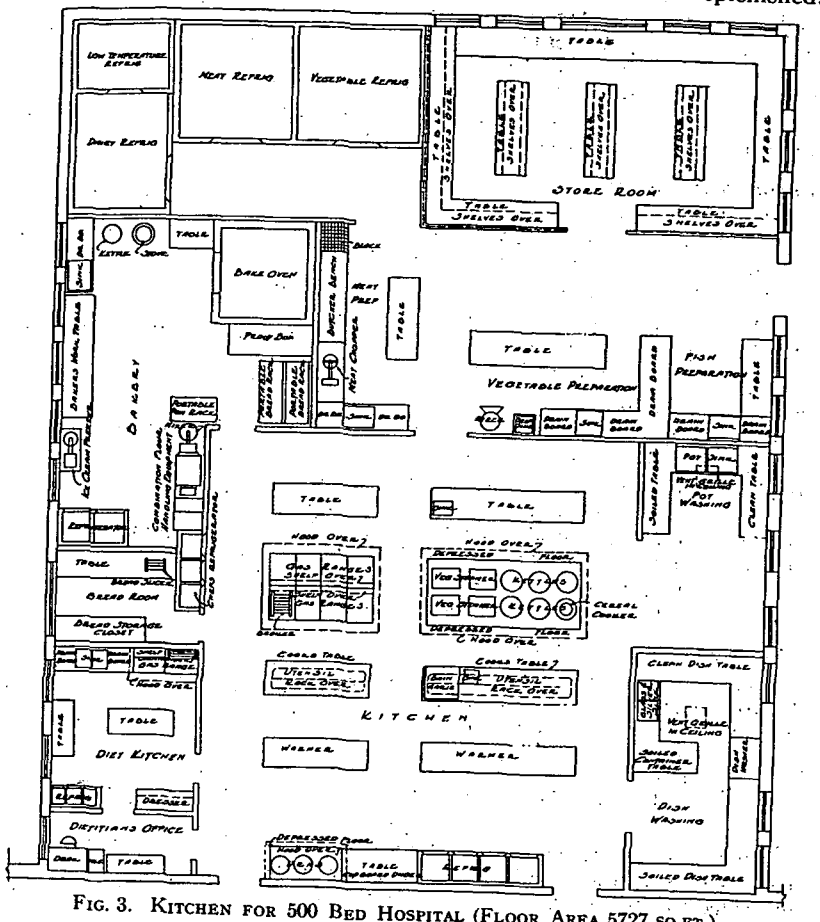


FIG. 3. KITCHEN FOR 500 BED HOSPITAL (FLOOR AREA 5727 SQ.FT.)

The requirements for steam tables are given hereinbefore under *Steam Tables*. Cold pans are about 24 in. wide and various lengths, and are refrigerated by ice or coils. Probably 4 ft. long would be the minimum length cold pan that should be installed.

A small sink should be provided behind the cafeteria rail and convenient to it.

Fig. 3 shows a kitchen for a 500 bed hospital.

Fig. 4 shows a kitchen for a 500 room hotel.

Water Requirements

Hot water requirements for kitchens may be taken as 20 gal. per hour for each sink faucet and 40 gal. per hour per 1000 pieces capacity per hour of dishwasher. There is a peak load which occurs at dish washing time, and must be met either by instantaneous heaters or by a storage type heater. The requirements of the dish washing machine are somewhat under control of the operator, for by more liberal use of steam less hot water is used, and vice-versa.

Cold water requirements are approximately double the hot water requirements but will easily be met through pipes of ample size.

Steam Requirements

The dish washing machine will consume from 50 to 100 lb. of steam per 1000 pieces capacity of machine, per hour. An allowance of 150 lb. steam per person, per hour will meet all steam requirements for kitchen except dish washing machine and water heating.

The average steam requirements for a kitchen serving 300 to 500 persons will be cared for by a 25 to 30 hp. boiler. The annual consumption of such a kitchen will be about 2,000,000 lb. of steam.

Power Requirements

Dish washing machines require 1 to 2 hp. per 5000 pieces capacity per hour, to drive, with the smallest machine using ½ hp. motor. Kitchen mixing machines take ½ to 1 hp.; bake shop combinations 2 hp. per barrel rating of machine. The 17 in. meat, food and vegetable choppers require 1 hp. and the 20 in. size requires 2 hp. Coffee grinders, knife polishers, silver burnishers need nominal amounts, about ¼ hp. Vegetable peelers take ¼ to 1 hp. according to size. Allow ½ hp. for a 25 qt. ice cream freezer and 1 hp. for 40 qt. size.

Electric Cooking Requirements

In a complete electric kitchen, *i.e.*, one in which ranges, broilers and hot-plates are electric, the watts required for a complete meal will average as follows; which are minimum:

General restaurant	400 to 500 watts
Institution kitchen	175 to 200 watts
Colleges, boarding schools, etc.	250 to 350 watts
Clubs, etc.	450 to 600 watts

Electricity is subject to considerable abuse, resulting in waste, unless care is used in its operation. It is easily possible for the figures to be exceeded by 100 per cent and probably that they always will be exceeded by some amount.

Steam Pressures

Not less than 30 lb. gage, and not over 50 lb. are the usual pressure limits for steam cooking. Lower pressures down to 1 lb. are ample for warmers, but the steam kettles require higher pressures and it is customary to carry the higher pressures mentioned on all equipment. All jacketed pots, have safety valves usually set at 50 lb. and usually vacuum breakers are required on the jacketed fixtures to prevent collapse under vacuum conditions.

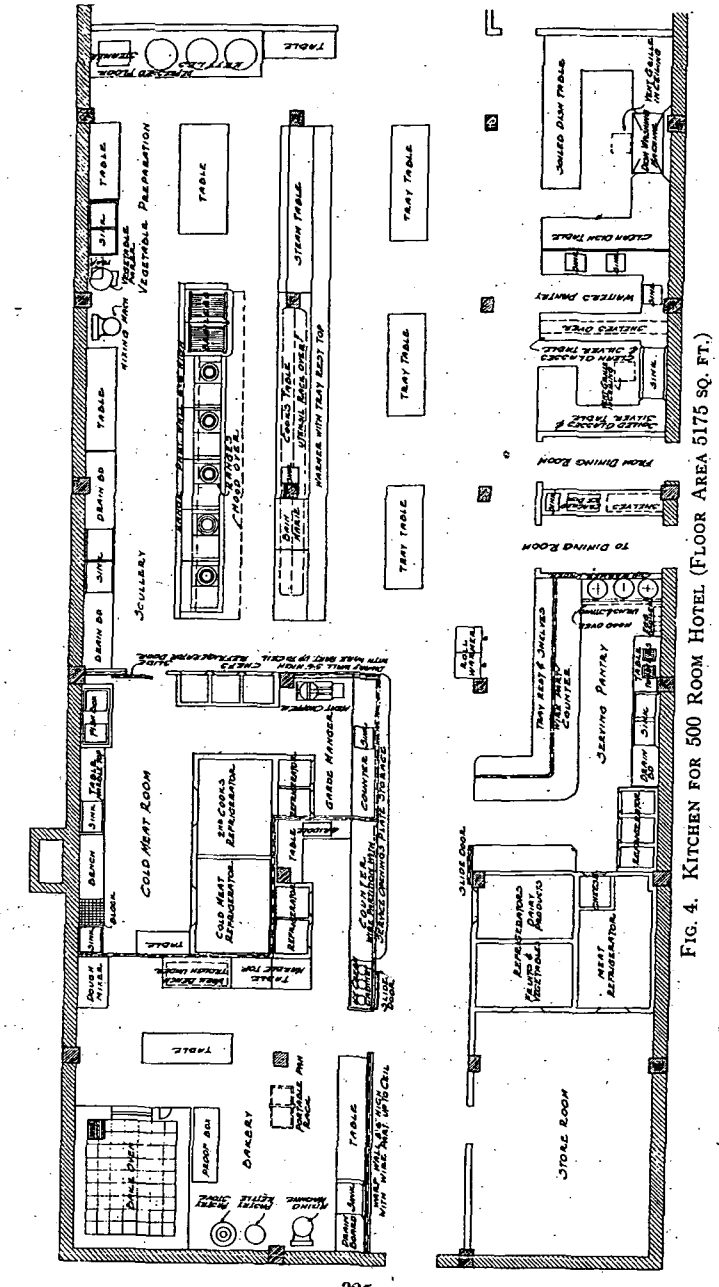


FIG. 4. KITCHEN FOR 500 ROOM HOTEL (FLOOR AREA 5175 SQ. FT.)

Water Connections

Hot and cold water connections to sinks are ¾ in.; hot water only is provided for dish washer from ½ to 1¼ in. according to size; ½ in. hot and cold water to "bain marie;" and ½ in. cold and hot water to coffee urns. Stock kettles, soup kettles, vegetable steamers, roasting steamers and potato peeler sink are frequently provided with a ½ in. faucet over each of them, supported independent of the fixture. Generally hot water only is so connected. These are not an absolute necessity but often a great convenience. Drinking fountains and water coolers require ½ in. cold water.

In sizing mains to care for two or more items make the mains about one half the sum of the areas of the branches.

Steam Supply Connections

Steam connections to jacketed kettles, soup kettles, vegetable steamers, steam tables, coffee urns, plate warmers and roll warmers are ½ in. for smaller sizes and ¾ in. for larger sizes and in cases where runs are long. Steam connections to dish washing machines are ½ to 1¼ in. according to size.

In sizing mains to take care of two or more items make the area of same about one half the sum of the branch areas, keeping the sizes well up, toward the ends of the runs.

Return Connections

Return connections are uniformly ½ in. size and are made to all equipment having steam connections except the spray to dishwashing machine. However the coil in this machine requires a return connection. Each unit or separate coil should be provided with a ½ in. thermostatic trap. If more than one unit or coil is connected to the same trap air binding will result. Connections of the same size are made to return mains.

Gas Connections

The proper manner is to obtain from the manufacturer, the gas consumption per hour of the different fixtures, to be used and size the gas pipes accordingly. Excellent tables for this purpose, when the gas consumption and length of run are known, are given by the *American Gas Association*.

As an approximation the following is given as sizes of connections commonly found in equipment of average size. Bake shop oven 1¼ in.; pastry oven ¾ in.; dish washing machines ¾ to 1½ in.; broilers 1 to 1¼ in.; ranges 1 to 2 in.; small ranges in diet kitchens 1 in.; salamanders and warmers ¾ in. and steam tables 1 in.

Grease Traps

The dish washing machine, all pot sinks, pan sinks and any sinks into which grease may find its way should be provided with grease traps. When grease traps on the individual fixtures are used the cold water supply to the fixture is connected to pass through the jacket of the grease trap.

HOSPITAL EQUIPMENT

Every modern hospital must sterilize all instruments and utensils used in operations and treatments, all dressings before being used, all bed pans from wards and rooms, the baby's milk and the bottle in which it is served. Provision should also be made to sterilize mattresses, bedding and similar articles and also dishes when occasion arises. A plentiful supply of sterilized water and distilled water must also be provided. Hospitals for mental and nervous diseases must include hydro-therapy and electro-therapy treatment. The equipment with which this chapter deals is largely, but not altogether, sterilizers.

Instrument, dressing, utensil, dish and mattress sterilizers are usually rated by their internal dimensions in inches; water sterilizers by the gallons capacity of each of the two reservoirs, water stills by their capacity in gallons and pasteurizers and bottle sterilizers by their capacity in 8 oz. bottles. The method of rating other hospital equipment will be referred to later.

Selection of Type of Sterilizers

Sterilizers and water stills may be had heated either by steam, electricity, gas, kerosene or gasoline; the preference being in the order named. Steam is the only method, however, for which the entire line of sterilizers are ordinarily made. They are simpler, contain less equipment liable to derangement, quicker in operation and cheaper both to install and operate than those heated by any other method. Electrically heated sterilizers, in practice, are confined to the smaller sizes, and such as for dentists' and doctors' treatment rooms outside of hospitals.

Electricity is superior to any other method only in one case, *i.e.*, the solution warmer, where due to its adaptability to automatic control it is preferred to any other method.

Cost of Operation

The cost of operation of steam sterilizer equipment is very little more than the cost of keeping steam constantly available and the amount of use has little effect on the total cost of operation. The cost of operation of electric sterilizers may be considerable, depending upon how much they are used and the cost of *standby* service for them. This will be seen when it is noted that the smallest instrument sterilizer is rated at 2200 watts and the largest dressing sterilizer at 12,000 watts.

The cost of operation of gas, kerosene and gasoline heated sterilizers is much more than for steam heated ones but usually less than for electric heated ones, depending entirely on the amount of use.

Open and Closed Sterilizers

There are two general classes of sterilizer, *i.e.*, the open type in which the articles to be sterilized are immersed in a water bath heated by steam coils, the limiting temperature obviously being 212 deg. fahr., and the closed type in which there is no water bath and the articles to be sterilized are brought into temperatures corresponding to steam at 40 to 60 lb. pressure per square inch.

The former is the older type and has the disadvantage of depositing

lime or other impurities, which may be in the water, on the instruments, etc., sometimes requiring them to be dried before storing. The latter type is the newer one, and obviously provides better sterilization by the higher temperatures obtainable, does not deposit impurities of the water on the instruments, and the articles are dry when removed from the sterilizer. Obviously sterilizers for dressings and fabrics must be of the latter type.

There is considerable tendency now to the use of so-called *built-in sterilizers* in the operating suites and other places where several sterilizers are installed at one point. Only pressure type sterilizers, which are loaded and unloaded from one end, are adaptable to this arrangement. With this method simply a thin partition is built flush with the sterilizer fronts, with only the doors, gages and operation valves visible in the rooms, the bodies projecting into an unfinished space behind the partition. This space must of course be accessible for repairs.

Proportioning Equipment

It is extremely difficult to lay down fixed rules as to the number and size of sterilizers to be installed in a hospital because requirements vary so widely and the technique followed by different hospital managements likewise varies widely.

However an attempt will be made to give some idea of the equipment considered sufficient under ordinary conditions. The number of major and minor operating rooms are fixed by considerations beyond the scope of this chapter.

One 16 in. x 24 in. dressing sterilizer will care for two major operating rooms and possibly for three, but for more than two such rooms it is better to provide a 16 in. x 36 in. size or better still to install two 16 in. x 24 in. sterilizers. The use of two sterilizers makes provision for breakdown service and in addition one of them may be used as a pressure utensil sterilizer, in some cases doing away with the necessity of installing a separate sterilizer for utensils.

One 20 in. x 20 in. x 24 in. open type, utensil sterilizer will care for two major operating rooms, unless the work is very heavy in which case one such sterilizer should be provided for each room.

One 9 in. x 10 in. x 20 in. open type, instrument sterilizer should be provided for each major operating room, although one 10 in. x 12 in. x 22 in. may serve two such rooms. The 12 in. x 16 in. x 24 in. instrument sterilizer finds its use where it is convenient to sterilize from three or more major operating rooms at one place.

One 14 in. x 22 in. (the smallest size advisable to use) pressure type, instrument sterilizer will easily serve two major operating rooms.

A small hospital might install one 20 in. x 28 in. pressure type dressing sterilizer which would serve both for dressings and utensils, but of course no breakdown service would thereby be provided.

From the references to both open and closed sterilizers it will of course be understood that both types for the same purpose are not to be installed. It is simply a choice of one type or the other for a given purpose.

Water sterilizers usually consist of twin reservoirs of the same capacity mounted on one frame. One reservoir is for water kept hot by steam coil

in the reservoir and the other somewhat cooled by circulating cold water through a coil in the reservoir. Both reservoirs of course have provisions for sterilizing their contents.

Water stills, when so ordered, are part of the water sterilizing unit and consist of still and reservoir, generally mounted between the two water reservoirs.

Water sterilizers are available in sizes from 6 to 100 gal. capacity of each reservoir and stills in capacities of 1–3 and 6 gal. reservoir capacity. The total capacity of the two water reservoirs on the water sterilizer should range between 5 and 10 gal. per major operation per day, as it is preferable to start with full tanks in the morning and have sufficient supply for the entire day.

The 3 gal. still would suffice for hospitals up to 100 beds and the 6 gal. size for larger hospitals, in connection with the water sterilizers.

Stills of same capacity are obtainable independent of the water sterilizers. There will frequently be need for a 6 gal. separate still in the pharmacy and frequently one in the maternity department.

The dressing, instrument, utensil and water sterilizers listed above are primarily for the major operating rooms. Sterilized dressings are stored in sealed containers, easily handled, and it makes little difference whether the operating activities are scattered or concentrated. Obviously the instrument, utensil and water sterilizers must be in or adjacent to the operating rooms as instruments, utensils and water should not be carried very far. If operating rooms are scattered the sterilizer equipment, with exception of the dressing sterilizer, must be duplicated for each location.

The sterilizers should preferably be located in a room fitted up for the purpose, opening directly into the operating rooms. It is well to remember, however, that uncontrolled sources of heat, however small, in an operating room are to be avoided whenever possible. In hot countries this is very important, for oscillating fans are usually not allowable in such rooms.

Maternity department delivery rooms are operating rooms so far as this discussion is concerned and are to have the same equipment. Even when they are so located that they may be served from same sterilizers as other operating rooms, which is usually not the case, there is a tendency to provide separate equipment for this room to avoid any possibility of infection from outside sources. This applies to the dressing sterilizer as well as other sterilizers.

In each minor operating room where eye, ear, nose and throat operations are performed and in treatment rooms where minor operations of various kinds are performed, and in the dental clinic, if one is provided a small electric sterilizer, say 5 in. x 6 in. x 16 in. for instruments should be provided.

In the surgery and maternity departments, and at convenient locations to rooms and wards, blanket and solution warmers should generally be provided. They are available in sizes approximately 18 in. x 24 in. x 72 in. and 18 in. x 30 in. x 72 in. and are simply heated, metal cabinets, suitably divided into compartments, in which bedpans, blankets and solutions may be kept suitably warmed, ready for use.

For the wards and rooms they should be placed in or near the utility

rooms, hereafter referred to, because the bedpans are washed and sterilized after use in the utility rooms. The compartments for blankets and bedpans are better heated by steam but the one for solutions will be better heated by electricity due to the fact that to keep solutions at the proper temperature for immediate use accurate automatic control of the temperature is necessary and the electric heating is best adapted for this purpose. This compartment for solutions is not generally necessary, however, except in the surgery and maternity departments.

Surgical dressing rooms must have provision for sterilizing water, instruments and utensils. Dressings may be sterilized at the central station. If it is adjacent to the main sterilizing room the equipment there may be utilized, but if not adjacent and in a large hospital, separate sterilizing equipment should be provided for this room. In case the sterilizing equipment of the operating rooms are used for this purpose a little liberality in their equipment should be practiced.

For surgical dressing room in a small hospital a 6 gal. water sterilizer, one 8 in. x 9 in. x 18 in. instrument sterilizer and 16 in. x 15 in. x 20 in. utensil sterilizer will suffice. For larger hospitals the next size larger equipment in each case should be provided.

In the laboratory there should be installed an autoclave, which is simply a dressing sterilizer without the jacket, for the wet sterilizing of material. A 16 in. x 24 in. will suffice for a 100 bed hospital. Two larger sizes, approximately 18 in. x 26 in. and 22 in. x 30 in. are available for larger hospitals or for very busy laboratories.

Utility Rooms

So called *utility rooms* should be provided in all hospitals, one or more on each floor, depending upon the area served, for all bed patients. Separate utility rooms should be provided for surgical ward and maternity departments.

Each utility room should contain, in addition to combination sink and tray, one 20 in. x 20 in. x 24 in. utensil sterilizer and one bedpan sterilizer. Those serving surgical and maternity patients should also contain an 8 in. x 9 in. x 18 in. instrument sterilizer and a 10 to 15 gal. water sterilizer.

The bedpan sterilizer is a combination bedpan washer and sterilizer and is available only for steam heating. If steam is not available simply a bedpan washer, which uses hot water but no steam, should be provided for washing bedpans and a 16 in. x 15 in. x 20 in. utensil sterilizer alongside the washer must be provided solely for the purpose of sterilizing bedpans. The utensil sterilizer of course may be for gas or electric heat.

Nursery

In the nursery equipment for pasteurizing milk and sterilizing milk bottles must be provided. In a small hospital this may be a combined pasteurizing and sterilizing outfit but in larger ones time will be conserved by installing separate pasteurizing and bottle sterilizing equipment. Pasteurizers are obtainable in 54–72–144 and 288 bottle capacity, 8 oz. nursing bottles. About one hour is required for a cycle as laws frequently require the pasteurizing process to consume 30 min. When bottle

sterilizing is done separately a pressure type sterilizer for nursing bottles is provided. Such a sterilizer must be used for no other purpose.

Sterilized water of course is required in the nursery and various considerations may decide whether or not a small water sterilizer must be installed there.

Special Sterilization

Where contagious diseases may be handled provision should be made for dish sterilization. On a large scale dishes from contagious patients are sterilized in special sterilizing dish washing machines. On a small scale however, a 20 in. x 20 in. x 24 in. utensil sterilizer fitted with special racks will serve the purpose. The sterilizing dish washing machines are referred to in the section on kitchen equipment.

For sterilization of mattresses, see the laundry equipment section of this chapter.

Specifying Sterilizers

The different manufacturers have sizes of sterilizers which are approximately the same but not absolutely standardized as to sizes. It is therefore advisable when specifying sizes to give approximate inside dimensions and minimum capacity in cubic inches and in cases, like the mattress sterilizer referred to, where for some reason there are certain limitations on certain dimensions these limitations should be stated.

Piping Systems and Pipe Sizes

Steam and return pipe sizes for sterilizers are almost nominal and the amount of steam used by such equipment is so small as to be negligible if drawn from a central plant for the heating. More detailed data is given in tabular form hereinafter.

A ½ in. supply and return connection is ample for any utensil, instrument or dressing sterilizer. Water sterilizers up to 15 gal. use ¾ in. supply and ½ in. return, above that size 1 in. supply and ½ in. return. For the large mattress sterilizers use 1¼ in. supply and ¾ in. return. Water stills up to 6 gal. use ½ in. supply and return.

When sizing the steam and return mains it may be assumed that all sterilizers will be in use at one time in a small hospital and half of them in a large hospital. The mains can then be sized by the usual table of equalization of pipe sizes. A return main one half the diameter of the steam main, with ¾ in. as minimum size, may be used.

The uniform practice is to provide a thermostatic trap on the return from each coil or unit of the size given previously for return connection. The return main should itself be vented and condensation should return by gravity to a vented receiving tank.

When gas is used a ½ in. connection is made to each instrument, dressing and utensil sterilizer. Water sterilizers up to 15 gal. capacity should have ¾ in. gas line and above that size 1 in. line. The mains should be sized on an equalization basis same as explained for steam supply lines, assuming all sterilizers in use in a small hospital at the same time and half of them in a larger hospital.

Waste and Vent Systems

All open type sterilizers, *i.e.*, those in which the articles to be sterilized are more or less immersed in water which is in turn heated by the steam must have waste connections similar to plumbing fixtures. With the exception of the bedpan sterilizer in which the trap is part of the fixture, traps on these waste lines must be provided in the plumbing work, the sterilizer equipment merely including a valve on the waste line and pipe to floor or wall, as may be required.

Waste connections are seldom more than ¾ in. at the fixture, however, as the usual sanitary fittings for plumbing work are not standard in sizes less than 1¼ in. it is customary to provide traps and connections of that size from the wall or floor line, as the case may be, to the waste piping of the plumbing system.

Waste connections from bedpan sterilizers are uniformly made 3 in. and trap is part of fixture, connected to floor or wall as required. This sterilizer waste should be connected up to the drainage system similar to a slop sink or water closet.

Vent connections are also necessary on such sterilizers to avoid the nuisance of steam and vapor in large quantities escaping into the room when a sterilization is finished and the sterilizer opened. Such connections usually take the form of a combined overflow and vent, connected into the back side of the chamber near top. This combined connection is usually carried as one horizontal pipe to a suitable location, as close to the sterilizer as possible, where the vent is taken upward as directly as possible to atmosphere and the overflow and condensation waste taken from the bottom through a suitable trap and connected to the waste lines of the plumbing system or connected to the waste from the body of the sterilizer between trap and sterilizer.

The usual sizes of combination overflow and vent connections to open sterilizers are as follows: utensil sterilizers 1¼ in. up to 16 in. x 15 in. x 20 in. size and 2 in. for larger sizes; instrument sterilizers 1¼ in. for all sizes; milk pasteurizers and sterilizers 1¼ in. up to 72 bottle size and 2 in. for larger sizes and for bedpan sterilizers 2 in. Vents to atmosphere are same size as combination overflow and vent. The overflow connection to plumbing waste pipes from the combination vent and overflow is 1¼ in. in all sizes of all sterilizers and is generally connected to the waste from sterilizer body between trap and sterilizer.

Where practicable it is well to run the vents from sterilizer equipment through the roof separate from other plumbing vent lines and to make them extra heavy galvanized pipe for the large amount of condensation in them often destroys standard weight piping in the smaller sizes rather quickly. A 2 in. vent line will carry a half dozen sterilizers but in climates where freezing weather often occurs it is necessary to carry them at least 4 in. in size through the roof to avoid frosting over.

Care must be taken to see that the bases or heels of vent lines from sterilizer equipment are drained through a suitable trap into the waste lines of the plumbing system to take care of condensation in such lines which might otherwise cause a nuisance by draining back into sterilizer at the bottom of the line.

Closed, or pressure type, sterilizers, both jacketed and otherwise, require a vent to atmosphere connected to the chamber and provided with a valve. The relief valve, with which every closed sterilizer must be provided, is usually connected to this vent line on the line side of the control valve. These vents are made, generally ¾ in. from each sterilizer, but for reasons heretofore explained the vent lines, after wall or floor is reached, are made 1¼ in.; the bases or heels of vent pipes must be dripped into the plumbing system and the vents should be carried through the roof separately and often 4 in. or larger pipe is required through the roof for same reasons as in case of open sterilizers.

Sterilizer Data

Sterilizer data is given in tabular form and while this is not standard for all manufacturers it is intended to give a general idea of the various requirements. The dimensions of sterilizers of various manufacturers vary and likewise the capacity in cubic inches. The pounds of steam per sterilization would not be materially different for different makes of sterilizers of approximately the same size. The watts required in case of electric sterilizers would not be materially different for the combined requirements of an installation as a whole, but the electrical requirements of individual sterilizers of same kind and size vary considerably with the different manufacturers. For instance a 12 x 20 in. dressing sterilizer of one manufacturer is rated for 3500 watts and the same sterilizer of another at 6000 watts. Obviously the one at 6000 watts would heat up more quickly and more work could be done with it. If the 3500 watt sterilizer was connected on a line designed for 6000 watts no harm would result but some useless copper would have been used but if the converse were permitted disaster would result. So in layouts for electric sterilizers the actual requirements of the sterilizer to be used must be investigated.

Frequently, both open and closed sterilizers of all kinds, are provided with *condenser exhausts* which consist of a special ejector, manipulated by a valve, throwing a stream of cold water into the ejector.

Cylindrical Dressing Sterilizers

Sizes in In.	Internal Capacity Cu. In.	Pounds of Steam per Sterilization	Watts Required in Wiring
10″ x 20″	1571	10	4000
12″ x 20″	2260	12	6000
14″ x 22″	3388	14	6000
16″ x 24″	4824	18	6000
16″ x 36″	7236	24	6000
16″ x 48″	9648	31	12000
16″ x 60″	12060	39	12000
20″ x 28″	8792	30	12000
20″ x 36″	11304	37	12000
20″ x 48″	15072	47	12000

Rectangular Dressing Sterilizers

24″ x 24″ x 36″	20736	Approx. 55	Not standard
24″ x 24″ x 48″	27648	Approx. 70	Not standard
24″ x 24″ x 60″	34560	Approx. 88	Not standard

Open Type Utensil Sterilizers

SIZES IN IN.	INTERNAL CAPACITY CU. IN.	POUNDS OF STEAM PER STERILIZATION	WATTS REQUIRED IN WIRING
16″ x 15″ x 20″	4800	30	4400
20″ x 20″ x 24″	9600	50	6600

Open Type Instrument Sterilizers

8″ x 9″ x 18″	1296	6	2200
9″ x 10″ x 20″	1800	8	2200
10″ x 12″ x 22″	2640	10	4400
12″ x 16″ x 24″	4608	16	4400

Water Sterilizers
(Steam and watts are for each reservoir)

6 gal.		15	3000
10 gal.		25	6000
15 gal.		37½	6000
20 gal.		50	12000
25 gal.		62½	12000
35 gal.		87½	18000
50 gal.		125	24000

This condenser exhaust is a part of the fixture, when used, and generally requires to waste over an open funnel, also part of the fixture, leading to the plumbing system waste through a suitable trap or connected to waste pipe from sterilizer chamber, between chamber and trap. Where separately connected a 1¼ in. trap should be provided although the outlet of the funnel is smaller than that size. The purpose of the open funnel is to prevent the creation of a pressure on the plumbing system which is not permissible.

A ½ in. water supply connection should be made to each sterilizer provided with this ejector. Such a pipe will carry a large number of such ejectors for the reason that the operation requires only a short time and more than one sterilizer will seldom be ejecting at the same time. Any pressure above 25 lb. per square inch will operate these ejectors, the higher the pressure the more efficiently the work is done and the less the water is required. Cold water only is used.

CHAPTER XX

WATER SUPPLY SYSTEMS AND PIPING FOR BUILDINGS

Cold Water Supply, Risers and Connections, Pipe Sizes, Hot Water Supply, Sizes of Mains.

THE following gives a great deal of reliable data upon which to base water pipe sizes for plumbing fixtures, branches and mains, the former lack of which data has probably been due to the great number of variables which enter into their proper determination.

Plumbing fixtures in common use, having what is known as good water flow, deliver the quantities of water per outlet as given in Table 1.

Water flowing in pipes is retarded by friction, the extent of which depends upon the velocity, which is the cause of unsatisfactory service when pipes are too small. The amount of head necessary to overcome this friction is known as the friction head, which is usually expressed in feet. It is also known as pressure drop, usually expressed in pounds per square inch per 100 ft. of pipe. The total pressure needed to discharge a given quantity of water is the pressure necessary to overcome friction in the pipes (when horizontal) plus the static pressure when the discharge is higher than the supply.

Table 6 gives the water pressure required to deliver water to the top of a fixture up to 150 ft. in height, with 15 lb. pressure at the top branch. This table also gives the water pressure in pounds required to give adequate service at various vertical heights up to 150 ft.

The underlying principle involved in determining the proper pipe sizes for mains, risers and branches is to so regulate the size of these pipes that they will carry the maximum amount of water required of them and absorb by friction and static head, all the pressure at the source and still deliver water at the fixture in sufficient quantity but at a pressure practically equalling zero or slightly above except that due to velocity of flow through the fixture.

Table 1 gives the amount of water in gallons which should flow per minute for the number of fixtures indicated of each different type, together with the branch pipe size necessary to carry this amount of water with a pressure drop of 30 lb. per 100 ft. of run.

The volume of water required per fixture is reduced as the number of fixtures in each group is increased, to take care of the factor of probable use.

In estimating the pipe size for any part of a riser in a building of several stories, take 60 per cent of the water to be used on any floor and all floors above as determined from Table 1 and deduct 10 per cent for each floor

Material for this section was originally compiled for THE GUIDE by the late W. S. Timmis and has been revised for this edition by the following committee: Prof. S. E. Dibble, *chairman;* H. H. Angus, C. E. Hanson and Prof. G. L. Larson.

above. This reduction in estimated amount is to take care of probable use. Thus, if 100 gal. are used on each floor of a 10-story building the size or pipe will be determined as in Table 2:

The pressure drop of 30 lb. per 100 ft. of run will give satisfactory results for branches on the top floor but a higher pressure drop can be used on floors below corresponding with the pressures as given in Table 5 which show that for a building 100 ft. in height, a pressure drop of 100 lb. can be used on the fixture lowest branches and that for a building 50 ft.

TABLE 1. COLD WATER BRANCH SUPPLY SIZES FOR FIXTURES AND MAXIMUM FLOW IN GALLONS PER MINUTE

	NUMBER OF FIXTURES									
	1	2	4	8	12	16	24	32	40	
Water Closets—										
Gal. per Min.	8	16	24	48	60	80	96	128	150	Tanks
Pipe Size	½	¾	1	1¼	1½	1½	2	2	2	
Gal. per Min.	30	50	80	120	140	160	200	250	300	Flush
Pipe Size	1	1¼	1½	2	2	2	2½	2½	2½	Valves
Urinals—										
Gal. per Min.	6	12	20	32	42	56	72	90	120	Tanks
Pipe Size	½	¾	1	1¼	1¼	1¼	1½	2	2	
Gal. per Min.	25	37	45	75	85	100	125	150	175	Flush
Pipe Size	1	1¼	1¼	1½	1½	2	2	2	2	Valves
Lavatories and Wash Sinks— Based upon Each Faucet										
Gal. per Min.	4	8	12	24	30	40	48	64	75	
Pipe Size	½	½	¾	1	1	1¼	1¼	1½	1½	
Bath Tubs—										
Gal. per Min.	15	30	40	80	96	112	144	192	240	
Pipe Size	¾	1	1¼	1½	2	2	2	2½	2½	
Shower Baths—										
Gal. per Min.	8	16	32	64	96	128	192	256	320	8" rain
Pipe Size	½	¾	1¼	1½	2	2	2½	2½	3	Head
Acid and Slop Sinks, Manufacturing, Kitchen and Laundry—										
Gal. per Min.	15	25	40	64	84	96	120	150	200	per bibb
Pipe Size	¾	1	1¼	1½	1½	2	2	2	2½	per bibb

Note.—The above sizes are based upon a pressure drop of 30 lb. per 100 ft.

In estimating risers and mains, the number of gallons for W. C. and urinals where flush valves are used are to be as given for tanks.

The hot-water faucets are to be disregarded when estimating cold-water risers and mains.

in height, a pressure drop of 52 lb. can be used on the lowest fixture branches; Table 1, however, can be used with safety on any of the floors but will give pipe sizes larger than necessary for the lower floors in a very tall building.

Table 5 gives the amount of water in gallons which may be passed through pipes of ¾ in. to 4 in. diameter with pressure drop from 5 lb. to 150 lb. per 100 ft. of run. This table may be used in sizing horizontal and vertical mains.

For example, if the water main pressure available is known, say 90 lb., and the horizontal run from water main to vertical riser is 100 ft., and the vertical riser is 100 ft. to top branch; it will require 43.31 lb. for static head (see Table 6), and 15 lb. pressure at a minimum should be allowed for the uppermost fixture or a total of 58.31 lb. which would leave available for friction 90 − 53.31 = 16.69 for friction in 200 ft. run, or

8.34 lb. per 100 ft. The main can thus be sized from the 7 lb. pressure drop of Table 5.

TABLE 2. WATER RISERS FOR MANUFACTURING BUILDINGS, LOFT BUILDINGS, APARTMENT HOUSES, HOTELS

	G. P. M.	G. P. M.	PIPE SIZE WITH DROP PER 100 FT. RUN		
			5 lb.	10 lb.	20 lb.
10th Floor	100 x 0.60	60% = 60	2"	2"	1½"
10 and 9	200 x 0.60	90% = 108	2½"	2½"	1½"
10 and 9 and 8	300 x 0.60	80% = 144	3"	2½"	2"
10 to 7 incl.	400 x 0.60	70% = 168	3½"	3"	2½"
10 " 6 "	500 x 0.60	60% = 180	3½"	3"	2½"
10 " 5 "	600 x 0.60	50% = 180	3½"	3"	2½"
10 " 4 "	700 x 0.60	40% = 184	3½"	3"	2½"
10 " 3 "	800 x 0.60	40% = 192	3½"	3"	2½"
10 " 2 "	900 x 0.60	40% = 216	3½"	3"	2½"
10 " 1 "	1000 x 0.60	40% = 240	3½"	3"	2½"

Note.—For residences, use Table 1, and for the main supply use 25 per cent of total of gallons used by fixtures and then take pipe size from Table 5 on a basis of 10 lb. pressure drop per 100 ft. or less if water supply pressure is less than 50 lb.

TABLE 3. APARTMENT HOUSE SUPPLY RISERS

Based upon One, Two, and Three Baths per Apartment

ONE (1) BATH APARTMENT			TWO (2) BATH APARTMENT			THREE (3) BATH APARTMENT		
1 bath		15 gal.	2 baths		24 gal.	3 baths		30 gal.
1 W. C.		8 gal.	2 W. C.		14 gal.	3 W. C.		18 gal.
1 sink		4 gal.	1 sink		4 gal.	1 sink		4 gal.
1 lav.		4 gal.	2 lavs.		6 gal.	3 lavs.		9 gal.
		31 gals.			48 gals.			61 gals.
50% demand—15 gals. per min.			40%—20 gals. per min.			40%—24 gals. per min.		
		Riser			Riser			Riser
Top Floor	15 gal.	1¼"		20 gal.	1¼"		24 gal.	1¼"
Next	28 "	1¼"		38 "	1½"		43 "	2"
"	38 "	1½"		54 "	2"		64 "	2"
"	51 "	2"		68 "	2"		82 "	2"
"	60 "	2"		80 "	2"		96 "	2½"
"	67 "	2"		90 "	2"		108 "	2½"
"	71 "	2"		98 "	2½"		117 "	2½"
"	78 "	2"		104 "	2½"		124 "	2½"
"	81 "	2"		108 "	2½"		134 "	2½"
"	83 "	2"		110 "	2½"		143 "	2½"
"	84 "	2"		110 "	2½"		143 "	2½"
"	85 "	2"		110 "	2½"		143 "	2½"

Note.—The pipe sizes are based upon a drop of 10 lb. water pressure for each 100 ft. run. The size of branch for each Apartment should be not less than 1¼ in.

Example—What is the riser size needed for a six-story apartment house having one bath for each apartment?

Table 3 gives 2 in. diameter for all from four to twelve stories with 1¼ in. to supply the top floor and next to top and 1½ in. for floor below.

What is the size of riser needed for a twelve-story apartment house with three baths to each apartment?

Table 3 gives 2½ in. for all floors up to eighth floor, 2 in. for ninth, tenth and eleventh, and 1¼ in. for top floor.

What is the riser size for a two bath apartment six stories high?

Table 3 gives 2 in. for the first four floors with 1½ in. at fifth floor and 1¼ in. on the top floor.

TABLE 4. APARTMENT HOUSES. SIZES OF WATER SUPPLY MAINS* AND METERS

Based upon pressure drop of 10 lb. per 100 ft. run

FOR 4 AND 5 STORIES

Apartments per Floor

	FOUR		SIX		EIGHT		TEN	
	Gal.	Main	Gal.	Main	Gal.	Main	Gal.	Main
1 bath	120	2½"	160	3"	200	3"	240	3"
2 baths	160	3"	200	3"	240	3"	280	3"
3 baths	200	3"	240	3"	280	3"	320	3½"

FOR 6, 7 AND 8 STORIES

1 bath	150	2½"	190	3"	230	3"	270	3"
2 baths	190	3"	230	3"	270	3"	310	3½"
3 baths	230	3"	270	3"	310	3½"	350	3½"

FOR 9, 10, 11 AND 12 STORIES

1 bath	200	3"	250	3"	300	3½"	350	3½"
2 baths	250	3"	300	3½"	350	3½"	400	3½"
3 baths	300	3½"	350	3½"	400	3½"	450	4"

Note.—The gallons per minute given above are approximated maximum demand for conditions stated.

*Table 4 gives the sizes of mains for apartment houses of one, two or three baths for each apartment, and with four, six, eight or ten apartments per floor and from four to twelve stories in height.

Example.—What is the required size of water main for apartment house eight stories high, six apartments per floor, each having three baths?

Answer from Table 4 is 3 in.

Example.—What is the required size of main for a ten-story apartment house with six apartments per floor, each having two baths?

Answer from Table 4 is 3½ in. main.

TABLE 5. PIPES MAY BE SIZED FOR GIVING ANY DESIRED PRESSURE DROP PER 100 FT. OF RUN

FRICTION PRESSURE DROP LB. PER SQ. IN. PER 100 FT. RUN	PIPE SIZES IN INCHES								
	¾	1	1¼	1½	2	2½	3	3½	4
	Gallons per Minute								
5	5.4	11	19	30	62	109	171	252	353
7	6.4	13	23	36	74	129	203	298	418
10	7.6	15	27	43	88	154	242	357	499
20	10.8	22	38	61	125	218	343	504	706
30	13.2	27	47	76	153	267	420	618	864
40	15.0	31	54	86	176	308	485	714	998
50	17.0	35	60	96	197	345	542	800	1115
75	21.0	43	74	117	242	423	665	978	1365
100	24.0	49	85	136	278	485	769	1130	1578
125	27.0	55	96	152	311	544	858	1260	1765
150	30.0	60	105	166	341	598	939	1380	1930

TABLE 6. SHOWING WATER PRESSURE REQUIRED TO DELIVER WATER TO TOP OF VERTICAL RISER WITH 15 LB. PRESSURE AT THE TOP BRANCH AND TO GIVE ADEQUATE SERVICE AT VERTICAL HEIGHTS GIVEN

*WATER PRESSURE IN LB. REQUIRED TO DELIVER WATER TO TOP OF RISER WITH 15 LB. TERMINAL PRESSURE				STATIC HEAD IN LB. PER SQ. IN.	VERTICAL RISE OF WATER FROM MAIN TO HIGHEST FIXTURE BRANCH	**WATER PRESSURE IN LB. REQUIRED TO GIVE ADEQUATE SERVICE AT VERTICAL HEIGHTS GIVEN			
Pressure Drop per 100 Ft.						Horizontal Run from Supply to Riser			
5 lb.	7 lb.	10 lb.	20 lb.			25' 0"	50' 0"	75' 0"	100' 0"
15	15	15	15	0	0	22.8 lb.	25.3 lb.	27.8 lb.	30.3 lb.
20.5	20.7	21	22	4.33	10	28.1 "	30.6 "	33.1 "	35.6 "
25	25.4	26	28	8.66	20	33.5 "	36 "	38.5 "	41 "
29.5	30.1	31	34	12.99	30	38.8 "	41.3 "	43.8 "	46.3 "
35	35.8	37	41	17.32	40	44.1 "	46.6 "	49.1 "	51.6 "
39.5	40.5	42	47	21.65	50	49.5 "	52 "	54.5 "	57 "
44	45.2	47	53	25.99	60	54.8 "	57.3 "	59.8 "	62.3 "
49.5	50.9	53	60	30.32	70	60.1 "	62.6 "	65.1 "	67.6 "
54	55.6	58	64	34.65	80	65.2 "	67.7 "	70.2 "	72.7 "
58.5	60.3	63	72	38.98	90	70.8 "	73.3 "	75.8 "	78.3 "
64	66	69	79	43.31	100	76.1 "	78.6 "	81.1 "	83.6 "
68.5	70.7	74	85	47.64	110	81.5 "	84 "	86.5 "	89 "
73	75.4	79	91	51.97	120	86.8 "	89.3 "	91.8 "	94.3 "
77.5	80.1	84	97	56.30	130	92.1 "	94.6 "	97.1 "	99.6 "
83	85.9	90	104	60.63	140	97.5 "	100 "	102.5 "	105 "
87.5	90.5	95	110	64.96	150				

*The water pressures given in above table are the pressures at the base of the riser, necessary to deliver water to top of riser with a terminal pressure of 15 lb. when discharging the number of gallons per minute called for in Table 5, at the pressure drop indicated.

**Based upon 10 lb. pressure drop per 100 ft. run of pipe and a terminal pressure of 15 lb. at the uppermost fixture. A terminal pressure of 15 lb. has been selected for operation of flush valves. For terminal pressure of 10 lb., deduct 5 lb. from the figures given above; or for a terminal pressure of 5 lb. deduct 10 lb. from above values.

Example.—What are the sizes required for mains and branches in a building 100 ft. high, supplied with a water pressure of 75 lb. per square inch with 100 gal. of water per minute required on each floor?

This is worked out in Table 2 and gives the pipe sizes for the main riser with a 10 lb. drop for 100 ft. of run and shows that a 3 in. main, reduced to 2 in., would be required: branches to the various groups of fixtures can be taken from Tables 5 and 6. On the top floor it will be necessary to use a 1½ in. branch to carry 60 gal. per minute with a pressure drop of 30 lb. but that at 30 ft. vertically from the supply, a 1¼ in. branch pipe will carry 60 gal. per minute, therefore 1¼ in. pipe could be selected for this branch. Assuming that the pressure drop in the main riser is 10 lb. per 100 ft. run and the pressure drop on the top floor in the branch does not exceed 15 lb. in all and the static head for building 100 ft. as given in column 2 of Table 6 is 43.31 lb. making a total of 58.31 lb.; it will be seen that 75 lb.—58.31 lb., which equals 16.59 lb., is the amount of pressure over and above that required, and that this pressure can be utilized to overcome the friction drop in the main feed line running from the source of supply to the base of the riser.

From Table 2 it is found that 240 gal. per minute will flow at the first floor, and assuming that this water supply is to be brought in a main 300 ft. long; Table 5 will show that a 3½ in. supply would be necessary.

Example.—What pressure is required in the water supply main to give 15 lb. pressure at the uppermost fixture in a building where the riser is 100 ft. high and is located 75 ft. from the water main in a horizontal direction, when the other fixtures within the building are in use to their estimated average capacity?

Answer is found to be 75.8 lb. at the intersection of 100 ft. vertical height and 75 ft. horizontal run.

Note.—If only 10 lb. be required at the uppermost fixture, then 70.8 lb. would be the answer.

WHEN TANK IS ON ROOF

If tank is elevated about 35 ft. above highest fixture, which would be about 25 ft. above the roof, similar computations will apply for branch

connections and main risers except that the main riser will have its greatest diameter at the top. It will be seen that 35 ft. elevation will give the necessary 15 lb. pressure at the highest fixture and that the pressure drop may be made equal to the static head from the top fixtures down, or 40 lb. per 100.

FRICTION IN ELBOWS

Friction caused by elbows should be added to straight pipe friction. Each elbow in a line will add friction equal to a length of straight pipe forty times the diameter of the pipe:

Pipe Size	¾	1	1¼	1½	2	2½	3	3½	4
Equivalent length of straight pipe in feet	2.5	3.3	4.1	5	6.7	8.3	10	11.7	13.3

The water supply formula herewith makes it possible to accurately compute the flow of water in gallons through any pipe with any friction head and also gives formula for the additional head due to water entering the main, which, if extremely accurate calculations are necessary, should be added to the head required for friction; generally, however, this can be neglected as it is comparatively small.

WATER SUPPLY FORMULA

CF = cubic feet per minute discharged.
G = gallons per minute discharged.
H = friction head of water in feet = pressure × 2.31; if water is raised vertically, deduct number of feet raised, from head due to pressure.
L = length of pipe in feet—including horizontal and vertical runs.

$$CF = 0.16\sqrt{\frac{(3d)^5 \times 3\ H}{L}} \quad (1) \qquad G = 1.2\sqrt{\frac{(3d)^5 \times 3\ H}{L}} \quad (2)$$

$$H = \frac{(CF)^2 \times L}{.0768\ (3d)^5} \quad (3) \qquad H = \frac{(G)^2 \times L}{4.32\ (3d)^5} \quad (4)$$

The above formula neglects the head due to entry, which need not be computed except when L is very short. H_1 = head due to entry in feet.

$$H_1 = \left(\frac{0.83\ G}{d^2 \times 13}\right)^2 \text{ or } H_1 = \left(\frac{6.25\ CF}{d^2 \times 13}\right)^2$$

Example.—Required the discharge of a 2 in. main with pressure 30 lb. 100 ft. horizontal run and 30 ft. vertical run.

$H = 30 \times 2.31 - 30 = 39.3$. Formula (2) $G = 1.2\sqrt{\frac{(3 \times 2)^5 \times 3 \times 39.3}{100 + 30}} = 100.8$

In the above case the head due to entry would be $H_1 = \left(\frac{0.83 \times 100.8}{2 \times 2 \times 13}\right)^2 = 2.56$ ft.

Usually this can be neglected except for very close calculations.

HOT WATER SUPPLY

Tables 7, 8, 9, 10 and 11 give the hot-water requirements for several kinds of buildings in terms of gallons per maximum hour and per day.

Pipe sizes for hot-water systems may be calculated from the foregoing data on cold-water systems; using the same quantities for the gallons of hot water required per minute as is given for the cold water. It may be borne in mind that a column of hot water is lighter than one of cold water amounting to about 2½ ft. per 100 ft. in the height of columns of equal weight. In case the cold water must first be fed down from roof tanks to heaters in the basement and then back up to the top floor fixtures, the extra length of run must be taken into consideration. As a check on the total quantity of hot and cold water required per day it is well to know that this generally runs from 2 to 3 times the amount of hot water required and from 80 to 100 gal. per occupant of the building.

TABLE 7. HOT WATER REQUIREMENTS FOR APARTMENT BUILDINGS

Class	Hot-Water Fixtures per Apartment						Gallons Hot Water per Apartment per Maximum Hour
	Lavatories	Bath Tubs	Showers Over Tubs	Kitchen Sinks	Laundry Trays	Separate Showers	
A	1	1	1	1	2	0	25
A	2	2	1	1	2	0	30
A	2	2	2	1	2	0	35
A	2	1	1	1	2	1	55
B	1	1	0	1	2	0	20
C	1	1	0	1	1	0	15

Note.—The quantity of hot water required per day is usually about 10 times the maximum hour requirement.

TABLE 8. HOT WATER REQUIREMENTS FOR HOTELS

Class	Gallons		Add for Kitchens per Meal Capacity		Add for Laundry		
	Hot Water per H. W. Fixture per Day	Per H. W. Fixture per Maximum Hour	Per Day	Per Maximum Hour	Per Piece per Day	Per Washer per Day	Per Washer per Maximum Hour
High-class transient	85	6.8	3.0	1.0	1.0	1200	250
Medium-class transient	70	6.5	2.5	0.80	1.0	1000	200
Apartment hotels	50	5.0	2.0	0.60	1.0	1000	200

Note.—Instantaneous demand rate for laundry washers from 25 to 50 gal. per minute.

TABLE 9. HOT WATER REQUIREMENTS FOR OFFICE BUILDINGS

Class	Hot Water per Hot-Water Fixture	
	Per Day	Per Maximum Hour
Having hot water in public toilets only	50	5.0
Having hot water in private offices as well as in public toilets	30	3.0
For self-closing hot-water fixtures deduct	40%	25%

As a check on the sizes of hot-water mains, Table 8 will give safe sizes for gravity systems fed from roof tanks set not less than 20 ft. from the water line in tanks to the highest fixtures.

TABLE 10. SIZES OF HOT WATER MAINS

GALLONS PER MAXIMUM HOUR	SIZE OF HOT WATER MAIN, INCHES
500	2
750	2½
1000	2½
1250	3
1500	3
1750	3½
2000	3½
2500	4
3000	4

TABLE 11. HOT WATER REQUIREMENTS FOR HOSPITALS

	HOT WATER	HOT WATER
	Per Patient	Per Fixture
Gallons used per average day	82	48
Gallons used per maximum day	127	65
Average maximum rate of flow for 15 min. in gallons per hour	11	7
Maximum rate of flow for 15 min. in gallons per hour	19	8

Note.—The above values are based on Utility Demands of a Modern Hospital by Larson, Nelson and Rose. See JOURNAL, AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS, January 1928.

Note.—The hot water used is 25 per cent of total water requirements. The above requirements are for a hospital without a laundry.

TABLE 12. WATER REQUIREMENTS FOR HOSPITALS†

	TOTAL WATER	TOTAL WATER USED EXCLUSIVE OF AMOUNT USED IN TOILETS, SLOP SINKS, SOFTENER FLUSHING AND REFRIGERATION COOLING		COLD WATER USED EXCLUSIVE OF AMOUNT USED IN TOILETS, SLOP SINKS, SOFTENER FLUSHING AND REFRIGERATION COOLING	
	Per Patient*	Per Fixture	Per Patient	Per Fixture	Per Patient
Gallons used per average day	366	77	275	104	193
Gallons used per maximum day	527	116	423	174	296
Average maximum rate of flow for 15 min. in gallons per hour	29	7	25	8	14
Maximum rate of flow for 15 min. in gallons per hour	50	12	44	16	30

†The values given are based on Utility Demands of a Modern Hospital by Larson, Nelson and Rose. See JOURNAL, AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS, January 1928. (No laundry included.)

*The items in this column, include water used for flushing softeners and refrigeration condenser.

The total water used per patient day was 366 gal. and exclusive of softener flushing and refrigeration condenser requirements was 308 gal. On the latter basis, the water used per occupant day was 127 gal. Laundry requirements would be in addition to above amounts.

CHAPTER XXI

PIPE AND FITTINGS

Standard Dimensions, Composition of Material, Copper and Brass, Roughing-In Dimensions, Design of Fittings.

DURING the past 20 years in particular there has been a remarkable development in the wrought tubular industry, including the tonnage used, the capacity of mills, diversity of pipe service, and improvements in the material itself.

The factors which control the characteristics and properties, and thus produce the modern improvement in various tubular materials, are the facilities of the manufacturer; the special processes employed; the availability and quality of raw materials and the ideals and skill of the men in the organization.

Among modern improvements none have received greater attention than the efforts to produce a uniform quality of wrought pipe. To secure and maintain uniformity, necessitates complete control of all materials and manufacturing operations—from ore to finished product. This practice of producing uniform skelp and its fabrication into finished tubular products is supplemented by a mechanical process of roll-knobbing, to make the metal more uniformly dense when there is any tendency to physical irregularity in this respect.

Another condition which gives rise to electrolytic centers and pitting is the presence of irregular areas of heavy welding-scale on the surface of the finished product, caused by oxidation at the high temperature of welding. This scale is strongly electro-negative to iron, like copper, and should therefore be removed in the interest of preventing corrosion.

Other advantages of having the scale removed from pipe are: its clean, smooth surfaces present an ideal base for the adherence of a galvanizing coating, full working capacity is assured (the interior being free from any obstructions tending to reduce the flow), troubles caused by the deposit of scale in valves, strainers, and other apparatus, are practically eliminated and pitting by corrosion is materially reduced.

Scale removal, where accomplished in the process of manufacture, is done by passing the oversize pipe through a series of finishing rolls (after its temperature has been reduced to about 1800 deg. fahr.) which rolls reduce it to the proper size and also crack the hardened welding-scale from both the inside and the outside of the pipe. The loose scale is then washed or blown off. While with such expedients considerable improvement has been attained, the fact still remains that the life of pipe is governed largely by installation conditions, and no matter how well made

Material for this Chapter was prepared especially by S. E. Dibble, Thomas Dugan, James Ashton and G. Schneider.

Table 1. Standard Wrought Pipe

Table of Standard Dimensions

Size Inches	Diameters		Nominal Thickness Inches	Circumference		Transverse Areas			Length of Pipe per Square Foot of		Nominal Weight per Foot	
	External Inches	Approximate Internal Inches		External Inches	Internal Inches	External Sq. In.	Internal Sq. In.	Metal Sq. In.	External Surface	Internal Surface	Plain Ends	Threaded and Coupled
⅛	0.405	0.269	0.068	1.272	0.845	0.129	0.057	0.072	9.431	14.199	0.244	0.245
¼	0.540	0.364	0.088	1.696	1.144	0.229	0.104	0.125	7.073	10.493	0.424	0.425
⅜	0.675	0.493	0.091	2.121	1.549	0.358	0.191	0.167	5.658	7.747	0.567	0.568
½	0.840	0.622	0.109	2.639	1.954	0.554	0.304	0.250	4.547	6.141	0.850	0.852
¾	1.050	0.824	0.113	3.299	2.589	0.866	0.533	0.333	3.637	4.635	1.130	1.134
1	1.315	1.049	0.133	4.131	3.296	1.358	0.864	0.494	2.904	3.641	1.678	1.684
1¼	1.660	1.380	0.140	5.215	4.335	2.164	1.495	0.669	2.301	2.767	2.272	2.281
1½	1.900	1.610	0.145	5.969	5.058	2.835	2.036	0.799	2.010	2.372	2.717	2.731
2	2.375	2.067	0.154	7.461	6.494	4.430	3.355	1.075	1.608	1.847	3.652	3.678
2½	2.875	2.469	0.203	9.032	7.757	6.492	4.788	1.704	1.328	1.547	5.793	5.819
3	3.500	3.068	0.216	10.996	9.638	9.621	7.393	2.228	1.091	1.245	7.575	7.616
3½	4.000	3.548	0.226	12.566	11.146	12.566	9.886	2.680	0.954	1.076	9.109	9.202
4	4.500	4.026	0.237	14.137	12.648	15.904	12.730	3.174	0.848	0.948	10.790	10.889
4½	5.000	4.506	0.247	15.708	14.156	19.635	15.947	3.688	0.763	0.847	12.538	12.642
5	5.563	5.047	0.258	17.477	15.856	24.306	20.006	4.300	0.686	0.756	14.617	14.810
6	6.625	6.065	0.280	20.813	19.054	34.472	28.891	5.581	0.576	0.629	18.974	19.185
7	7.625	7.023	0.301	23.955	22.063	45.664	38.738	6.926	0.500	0.543	23.544	23.769
8	8.625	8.071	0.277	27.096	25.356	58.426	51.161	7.265	0.442	0.473	24.696	25.000
8	8.625	7.981	0.322	27.096	25.073	58.426	50.027	8.399	0.442	0.478	28.554	28.809
9	9.625	8.941	0.342	30.238	28.089	72.760	62.786	9.974	0.396	0.427	33.907	34.188
10	10.750	10.192	0.279	33.772	32.019	90.763	81.585	9.178	0.355	0.374	31.201	32.000
10	10.750	10.136	0.307	33.772	31.843	90.763	80.691	10.072	0.355	0.376	34.240	35.000
10	10.750	10.020	0.365	33.772	31.479	90.763	78.855	11.908	0.355	0.381	40.483	41.132
11	11.750	11.000	0.375	36.914	34.558	108.434	95.033	13.401	0.325	0.347	45.557	46.247
12	12.750	12.090	0.330	40.055	37.982	127.676	114.800	12.876	0.299	0.315	43.773	45.000
12	12.750	12.000	0.375	40.055	37.699	127.676	113.097	14.579	0.299	0.318	49.562	50.706

or uniform the pipe may be, its life, particularly under severe corrosion conditions; such as, hot-water supply lines, boiler feed and return lines, is limited, and some protective measures are necessary to secure a longer life.

The electrolytic theory of corrosion, as formulated in 1903 by Dr. Whitney, led to the development of certain protective methods for closed

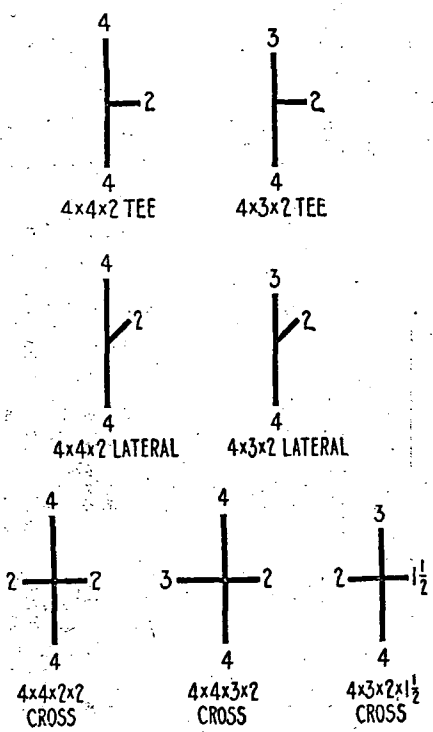


Fig. 1. Usual Method of Designating Fittings

water systems, which are based on the removal of dissolved oxygen from the water. Careful experiments in various research laboratories have demonstrated that the amount of corrosion found in such systems is almost directly proportional to the amount of oxygen in solution, and varies with the temperature.

All reliable data on this subject indicate that the composition of the iron—*i.e.*, the varying amount of carbon, phosphorous, manganese, sulphur, silicon, oxides, slag and copper usually found in wrought iron and soft steel—makes very little difference in the amount or character of

Table 2. Extra Strong Wrought Pipe

Table of Standard Dimensions

Size Inches	Diameters		Nominal Thickness Inches	Circumference		Transverse Area			Length per Square Foot of		Length of Pipe Containing One Cubic Foot Feet	Nominal Weight per Foot Plain Ends Pounds
	External Inches	Approximate Internal Inches		External Inches	Internal Inches	External Sq. In.	Internal Sq. In.	Metal Sq. In.	External Surface	Internal Surface		
⅛	0.405	0.215	0.095	1.272	0.675	0.129	0.036	0.093	9.431	17.766	3966.392	0.314
¼	0.540	0.302	0.119	1.696	0.949	0.229	0.072	0.157	7.073	12.648	2010.290	0.535
⅜	0.675	0.423	0.126	2.121	1.329	0.358	0.141	0.217	5.658	9.030	1024.689	0.738
½	0.840	0.546	0.147	2.639	1.715	0.554	0.234	0.320	4.547	6.995	615.017	1.087
¾	1.050	0.742	0.154	3.299	2.331	0.866	0.433	0.433	3.637	5.147	333.016	1.473
1	1.315	0.957	0.179	4.131	3.007	1.358	0.719	0.639	2.904	3.991	200.193	2.171
1¼	1.660	1.278	0.191	5.215	4.015	2.164	1.283	0.881	2.301	2.988	112.256	2.996
1½	1.900	1.500	0.200	5.969	4.712	2.835	1.767	1.068	2.010	2.546	81.487	3.631
2	2.375	1.939	0.218	7.461	6.092	4.430	2.953	1.477	1.608	1.969	48.766	5.022
2½	2.875	2.323	0.276	9.032	7.298	6.492	4.238	2.254	1.328	1.644	33.976	7.661
3	3.500	2.900	0.300	10.996	9.111	9.621	6.605	3.016	1.091	1.317	21.801	10.252
3½	4.000	3.364	0.318	12.566	10.568	12.566	8.888	3.678	0.954	1.135	16.202	12.505
4	4.500	3.826	0.337	14.137	12.020	15.904	11.497	4.407	0.848	0.998	12.525	14.983
4½	5.000	4.290	0.355	15.708	13.477	19.635	14.455	5.180	0.763	0.890	9.962	17.611
5	5.563	4.813	0.375	17.477	15.120	24.306	18.194	6.112	0.686	0.793	7.915	20.778
6	6.625	5.761	0.432	20.813	18.099	34.472	26.067	8.405	0.576	0.663	5.524	28.573
7	7.625	6.625	0.500	23.955	20.813	45.664	34.472	11.192	0.500	0.576	4.177	38.048
8	8.625	7.625	0.500	27.096	23.955	58.426	45.663	12.763	0.442	0.500	3.154	43.388
9	9.625	8.625	0.500	30.238	27.096	72.760	58.426	14.334	0.396	0.442	2.464	48.728
10	10.750	9.750	0.500	33.772	30.631	90.763	74.662	16.101	0.355	0.391	1.929	54.735
11	11.750	10.750	0.500	36.914	33.772	108.434	90.763	17.671	0.325	0.355	1.587	60.075
12	12.750	11.750	0.500	40.055	36.914	127.676	108.434	19.242	0.299	0.325	1.328	65.415

corrosion under water, although under atmospheric exposure the influence of composition is sometimes more marked.

In practice, oxygen removal has been accomplished in two ways, namely; by de-aerating the water mechanically; and by fixing the free oxygen by chemical combination. Suitable apparatus is now being manufactured for this purpose.

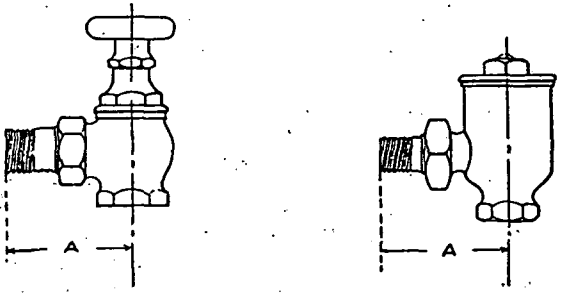


Fig. 2. Standard Roughing-in Dimensions

Angle Type Valves

Size of Valve	Dimension *A* Steam and Hot Water Angle Valves and Union Elbows Effective Jan. 1, 1926	Dimension *A* Modulating Valves Effective Jan. 1, 1926	Dimension *A* Return Line Vacuum Valves Effective Jan. 1, 1925
½″	2¼″	2¾″	3¼″
¾″	2¾″	2¾″	
1″	3″	3″	
1¼″	3½″	3½″	
1½″	3¾″	3¾″	
2″	4¼″	4¼″	
Tolerance	±⅛″	±⅛″	

The standardization of the Roughing-in Dimensions of Angle Steam and Hot Water, and Modulating Radiator Valves was made possible by the cooperation of the Manufacturers Standardization Society of the Valves and Fittings Industry.

Tables 1 and 2 give the important physical properties of Standard and Extra Heavy Wrought Pipe.

Copper and Brass Pipe

Copper and brass tubing are commonly stocked and supplied in sizes varying from ⅛ to 10 in. o. d. and in gages from 2 to 25 B. & S. and Stubbs.

Copper and brass pipes are stocked and supplied in standard, extra heavy and double extra heavy iron pipe thicknesses and sizes. See Tables 1 and 2. Both tubing and piping are usually stocked in 12 ft. lengths, and can be obtained in lengths from 2 to 20 ft. or more if required.

The serviceability and usefulness of brass piping is due principally to its inherent resistance to corrosion. For this reason it is used for boiler

feed systems, water supply systems, and for other purposes where corrosion is an important consideration.

Corrosion is caused by the chemical interaction between the oxygen of the atmosphere and the metallic surfaces. In the case of closed water systems this applies also to the oxygen of the air dissolved in the water. This type of corrosion or oxidation is universal and is the chief cause of the deterioration and decay of metals and alloys used in engineering. Other types of corrosion or chemical decomposition frequently occur and are very often due to the action of acids on the metals.

In cities sulphur dioxide, chlorides, sulphides and other ingredients also have a distinct corrosive influence.

Copper or brass piping does not discolor the water, which it conveys, with rust. Due to its maintenance of a smooth, unrusted interior, full flow and pressure are continued throughout the life of the system, and piping friction losses do not increase with age of the system.

Certain special conditions conducive to corrosion may require special mixtures, in order to obtain for the piping systems the longest life. Where unusual factors of corrosion are present, the engineer or contractor should heed the recommendations of the pipe manufacturer. In all cases, pipe fittings should have approximately the same composition as the metal of the pipe itself.

FITTINGS

Fig. 1 shows the usual method of designating fittings.

The dimensions of cast-iron and malleable screw fittings should be in accordance with the standards approved by the *American Engineering Standards Committee*. Fig. 2 indicates the roughing-in dimensions for radiator valves and traps adopted as standard by the *Heating and Piping Contractors' National Association*.

CHAPTER XXII

DESIGN AND OPERATING DATA FOR MECHANICAL EQUIPMENT OF FEDERAL BUILDINGS UNDER CONTROL OF U. S. TREASURY DEPARTMENT

Heating Requirements, Boiler Capacity, Electric Requirements, Water Requirements, Elevator Requirements, Sanitary Equipment, Isolated Plants, Janitorial Service.

THE following data have been compiled by Nelson Thompson, Chief Mechanical and Electrical Engineer, Office of the Supervising Architect, U. S. Treasury Department, Washington, D. C., to show the principles upon which the installation and operation of the mechanical equipment of Federal Buildings under the control of the United States Treasury Department are based.

It is not intended to be of a highly technical or research character, but of a more practical nature, for the use of the busy architect or engineer in the general planning or arranging of mechanical equipment for buildings of this character.

While much of the data referred to do not pertain strictly to heating and ventilating, it is so related so as to come within the scope and practice of heating and ventilating engineers and will, it is hoped, be of general interest to those engaged in this field of work.

TABLE 1. APPROXIMATIONS USED IN STUDY AND DESIGN OF PLUMBING EQUIPMENT FOR SMALLER U. S. POST OFFICE AND COURT HOUSE BUILDINGS

FIXTURES	SMALL BUILDINGS 25 OR LESS EMPLOYEES	MEDIUM BUILDINGS 26 to 100 EMPLOYEES	LARGE BUILDINGS OVER 100 EMPLOYEES
Water closets	1 to 10	1 to 20	1 to 23
Urinals	1 to 25	1 to 30	1 to 46
Lavatories	1 to 15	1 to 20	1 to 30
Shower baths	1 to 50	1 to 50	1 to 50

In the smaller buildings toilet facilities for office floors where the number of employees is not known are estimated on the basis of one employee for each 100 sq. ft. of net office space, divided, about 70 per cent for men and 30 per cent for women.

Private toilets are always provided for the postmaster, judge and petit juries. They may also be provided for other officials in special cases.

Lavatories are installed in all office rooms or suites.

Fire hose are not installed in the small one story buildings. Where installed in larger buildings they are so located that no room is over 75 ft. from the hose cabinet.

Material for this Chapter was prepared especially for THE GUIDE by Nelson S. Thompson.

The size of the main sewer from the building to the city sewer is generally not less than 6 in.

Where sewers are combined, or where the sanitary sewer is less than 4 ft. below the basement floor, back water valves are installed to protect basement fixtures and areas. For combined sewers the roof water is separated, so far as possible, from the sanitary drainage.

A cleanout manhole is installed on the main sewer line just inside the basement wall to facilitate testing and cleaning the connection to the city sewer. If the center line of main sewer is more than 30 in. below the floor, cleanout manholes are made 22 x 40 in.

The minimum size of water service for any building is 1¼ in. without fire hose, and 2 in. with fire hose. All fire risers are 2 in. No meters are installed, but outlets are provided for same. Connections for fire lines are taken off just inside the main shut-off valve on street side of meter outlets.

HOT WATER HEATERS AND STORAGE TANKS

In the smaller buildings 20 gal. in the storage tank is allowed for each shower bath, 10 gal. for each sink and 5 gal. for each lavatory. This works out on an average in these buildings as a 65 gal. tank, a cast-iron water heater with 12 in. grate and an indirect type of heating element connected below the water line of the heating boiler.

In the larger buildings the storage tank is usually about 36 in. diameter by 8 ft. long, contains 424 gal. and has a copper steam coil of 36 lin. ft. 2 in. diameter tubing. The cast-iron water heater has an 18 in. grate.

DRINKING WATER

Consideration is not given to the installation of mechanically refrigerated drinking water systems in any building with less than 2,500,000 cu. ft. contents, nor where there are fewer than 20 drinking fountains or less than 500 occupants for the reason that from October 1, to April 1, iced-drinking water is not furnished in buildings located north of the 37th parallel of latitude. South of that line it is furnished the year around. The average cost of the ice purchased throughout the United States is 55 cents per 100 lb. and the consumption averages, north of the 37 parallel, in summer, 1½ lb. per day per occupant for the period of 180 days. No labor can be saved by mechanical refrigeration when fewer than 20 drinking fountains are to be iced daily.

In the smaller post offices and court houses the following rule is used:

Drinking fountains on the basis of one fountain for each 50 employees are to be installed in all large and small post-office workrooms. A drinking fountain is also to be installed in each corridor on upper floors in the smaller buildings. One pint of refrigerated drinking water per hour is allowed for each occupant.

HEATING

One-pipe steam distribution is used for small and medium sized buildings except where there is a central heating service, when the system in the building is so designed that the outside service can be used.

Boilers generally in the smaller buildings are single pass and in the larger buildings double pass firebox portable type. Care is taken to see that the architect provides a stack of ample size and height. In general, a fire-brick lined stack 21 x 21 in. inside is provided for the smaller buildings.

Fuel rooms are provided on a basis of 1 sq. ft. for each 1000 cu. ft. gross cubic contents of the building and are in no case less than 500 sq. ft. in floor area.

Mechanical ventilation is installed for court rooms and, sometimes, for other assembly rooms in larger buildings.

The ratio of direct steam radiation to the architectural cubic contents of the building will average 1 to 110.

CONDUIT AND WIRING

Ceiling lighting outlets in post-office working spaces are spaced approximately 10 ft. on centers. Each screen window has a bracket outlet. Lock box and similar screen sections have bracket outlet spaced approximately 3 ft. apart.

One city telephone per each 1200 sq. ft. of net floor area is about the average which must be provided for.

The illumination, exclusive of furniture lighting, is figured on the basis of one watt per square foot for all post-office working spaces, swing rooms, lobbies and office rooms and ¾ watt per square foot for corridors, toilets and similar rooms. Court rooms are figured at two watts per square foot. Boiler rooms and basement storage rooms are supplied with drop cord outlets, using 25 watt lamps, spaced approximately 15 ft. apart. One drop cord outlet is installed for gage light on the boiler. Fuel rooms have one drop cord outlet at the entrance.

ELEVATORS

Regularly, one passenger elevator is allowed for each 40,000 gross floor area above the first floor, and as a check against this, one elevator for every 300 occupants of the building above the first floor is used.

Elevators are located as close as possible to the entrances to the building. Not more than six elevators are placed in any one bank.

Elevator conditions in Federal Buildings are very different from those obtained in high class office buildings—the service will not be so frequent.

MARINE HOSPITALS

None of the foregoing rules apply to Marine Hospitals. In fact, few rules can be established for the design of the mechanical equipment of these establishments. Data for the equipment of a hospital recently designed by the Office of the Supervising Architect are as follows:

The kitchen is provided with hoods over the ranges, steam kettles, etc. Motor-driven fans exhaust from these hoods, giving 12 air changes per hour.

The main diet kitchen is equipped with a gas range about 30 in. long, a large refrigerator with brine coils supplied from the central refrigerating plant, and a steel table having mounted thereon a motor-driven fruit juice extractor and a small motor-driven mixing machine.

TABLE 2. MECHANICAL EQUIPMENT FOR U. S. MARINE HOSPITAL GROUP*

BOILERS		SQ. FT. STEAM RAD.	HOT WATER TANK AND HEATER CAPACITY		TOTAL HOT AND COLD WATER PER DAY PER OCCUPANT	NUMBER OF PLUMBING FIXTURES PER PATIENT			
No.	H. P. Each		For Toilets and Baths	For Kitchen and Laundry		W. C.	Urin.	Lav.	Bath Tubs
4	120	17,000	1400 gal. storage 2500 gal. per hr.	700 gal. storage 1500 gal. per hr.	200	1/9	1/18	1/6	1/12

Laundry

POUNDS DRY WASH PER WEEK	FLOOR SPACE	WASHERS		NO. 30 IN. EXTRACTORS	DRYING TUMBLER	POWER PRESSES FOR UNIFORMS	FLAT WORK IRONER
		No.	Size				
14,400	3740 sq. ft.	1	36"x54"	2	1	4–38"	110 in. 6 roll 65 lin. ft. per minute.

REFRIGERATION			KITCHENS		
Tons Capacity	Ice Made	Refrigerated Storage Space Cu Ft.	Floor Area	Diet Kitchen on each Floor of Hospital	Kettles and Steamers
8	1 ton	2400	2300 sq. ft.	13' x 20'	1–50 gal. 2–40 " 2–60 " 1–4 sect. steamer

RANGES, OVENS AND WARMERS

Gas range 8 ft. 0 in. long
Comb. gas and coal range, 8 ft. 0 in. "
Gas broiler, 3 ft. 0 in. "
Gas griddle and toaster, 3 ft. 0 in. "
4 compartment pastry oven.
20 sq. ft. baking shelves.

MACHINES

One–2 peck per minute paring machine.
One–2½ lb. per minute meat chopper.
One–80 qt. mixing machine and coffee grinder.
One–40 qt. ice cream freezer.

*Capacity: 249 beds for patients, 57 attendants, 26 nurses, 2 internes, 1 officer in charge, 4 junior medical officers and 4 administration assistants.

The serving and diet kitchens in the main building are each equipped with a household type gas range and an automatic electric refrigerator. As food for the wards will be distributed generally by means of insulated food carts direct from the main kitchen, diet kitchen equipment has been kept to the minimum.

In addition to the above equipment, however, two of the diet kitchens are provided with dishwashers with steam sterilizing equipment for use in case of contagious diseases.

The main serving kitchen and dining rooms are located on the main floor directly over the kitchen. An electric dumb-waiter is provided for carrying food between the kitchen and serving rooms. An average of 60 per cent of the patients in Public Health Service Hospitals are ambulant. This gives about 150 patients to be served from the main serving

kitchen. The serving kitchen is about 20 x 40 ft. and is arranged in cafeteria style. It has a steam table 10 ft. long, provided with meat, soup and vegetable dishes, and about 30 lin. ft. of counters with tray slides. This steam table and counter is ample to serve at least 300 people per hour, so that the 150 patients can be served in one-half hour. The counters and steam table are made of galvanized iron, finished with lacquer paint, and are equipped with solid nickel silver tops. They have storage shelves with sliding doors underneath.

The dining rooms for patients aggregate about 2500 sq. ft. or about 17 sq. ft. per person served.

A large dishwasher is located adjacent to the dining rooms, and a smaller dishwasher is located on the first floor to serve dining rooms on that floor, so that all dishes are washed on the same floor as that on which they are used, thereby greatly reducing the required capacity of the dumb-waiter.

Nurses and attendants are served in separate dining rooms on the same floor as the patients, and in a dining room on the first floor adjacent to the main kitchen.

OPERATING DATA ON 1400 BUILDINGS

TABLE 3. GENERAL SUMMARY OF OPERATING DATA FROM 1400 U. S. TREASURY DEPARTMENT BUILDINGS CONTAINING 1910 LOW PRESSURE AND 90 HIGH PRESSURE BOILERS, 775 ELEVATORS AND 8 ELECTRIC GENERATING PLANTS

VALUE OF BUILDINGS AND EQUIPMENT EXCLUSIVE OF LAND	VALUE OF MECHANICAL EQUIPMENT	YEARLY COST OF REPAIRS TO MECHANICAL EQUIPMENT	YEARLY COST OF OPERATING SUPPLIES	YEARLY COST OF LABOR	YEARLY COST OF REPAIRS TO BUILDING, VAULTS, NEW FURNITURE, FURNITURE REPAIRS, CARPETS, LIGHTING FIXTURES, ETC.
$500,000,000	$50,000,000	$550,000	$3,011,500	$6,500,000	$1,805,000

About 6000 engineers, janitors, laborers, firemen, charwomen, mechanics, etc., are employed to care for these buildings. There is approximately one employee of this character for each 100,000 cu. ft. of building content.

To approximate roughly, one mechanic or maintenance man proper is estimated for each 1,000,000 cu. ft. In addition, a fireman force is estimated on the following basis:

One man to each 800 to 1000 tons of coal fired when steam is generated the year round, or one man to each 400 to 500 tons when steam is generated during the heating season only. If an electric generating plant is operated, three additional watch engineers are required. The foregoing does not include the cleaning force.

In a building containing an electric generating plant and having a cubic content of about 18,000,000 cu. ft. using 9000 tons of coal, the force so obtained is split up about as follows:

One chief engineer, 4 assistant engineers, 1 plumber, 1 electrician, 14 engineer helpers (general mechanics, oilers, etc.) and 10 firemen.

A laborer is expected to keep clean, on an average, 6000 to 8000 sq. ft.

of floor area, while a charwoman (working five hours per day) is expected to keep clean 3000 sq. ft.

The average cost per square foot of net floor area for all items of maintenance and operation, both material and labor (except repairs), is about 25 cents in the new buildings and 30 cents in buildings of the older and more antiquated type.

The average cost of fuel and labor to heat the buildings, using bituminous coal (at approximately $5.33 per ton) is ¼ cent per cubic foot per annum.

TABLE 4. YEARLY COSTS OF REPAIRS TO THE MECHANICAL EQUIPMENT IN 1400 U. S. TREASURY DEPARTMENT BUILDINGS

Plumbing repairs, including new brass water piping	$148,753
Heating and ventilating apparatus	250,171
Elevator repairs and new elevators	102,221
Conduit and wiring	46,890
Pneumatic tubes	1,965
	$550,000

An analysis of all the Federal Buildings for which steam is purchased shows that north of Richmond, Va., approximately 5 lb. of steam is used per cubic foot per season for heating the buildings. This, of course, varies widely due to local conditions, winds, building construction, manner of operation, etc. In fact, in the north we will get, in the same State, variations running from 3 lb. of steam per cubic foot for one building to 7 lb. for another building.

Generally-speaking, an isolated electric generating plant begins to be feasible in a Federal Building when the full connected load is 150 k.w. or more, the annual current consumption 200,000 k.w.h. or more and

TABLE 5. YEARLY COSTS OF OPERATING SUPPLIES FOR 1400 U. S. TREASURY DEPARTMENT BUILDINGS

136,871 tons of bituminous coal, at an average cost of $5.33 delivered in the bunkers	$730,010
23,100 barrels of fuel oil, at an average cost of $1.42 per barrel delivered at building	32,802
Central Station Steam 294,625 thousand pounds	256,876
Natural gas for use as fuel in heating boilers, 97,777,000 cu. ft. at an average cost of 34.8 cents per thousand cubic feet	34,000
(It is found that 25,000 cu. ft. of natural gas is equivalent to one ton of good bituminous coal, and that on the average 6½ cu. ft. of natural gas is burned per cubic foot of building content.)	
Water for these buildings (average water consumption 25 gal. daily per employees, except in marine hospitals, where it runs up to 200 gal. daily)	200,000
Electric light bulbs	72,114
(Approximately one new electric light bulb is required for each electric light socket in the building per annum. The light is used on an average in all these buildings about 1500 hours per annum.)	
Electricity for light and power for all purposes 26,800,000 k.w.h., at an average cost of 4.07 cents	1,090,828
Oil, waste, engineers' supplies, ice, soap, brooms, janitor's supplies, etc.	594,870
	$3,011,500

TABLE 6. YEARLY COSTS OF REPAIRS TO THE 1400 BUILDINGS UNDER THE CONTROL OF THE U. S. TREASURY DEPARTMENT

BUILDING REPAIRS REMODELING, PAINTING, ETC.	NEW VAULTS AND REPAIRS TO OLD ONES	NEW FURNITURE, FURNITURE REPAIRS, CARPETS, LIGHTING FIXTURES, ETC.
$930,000.00	$100,000.00	$775,000.00

ISOLATED ELECTRIC PLANTS

TABLE 7. DATA RELATING TO ISOLATED ELECTRIC GENERATING PLANT U. S. TREASURY DEPARTMENT BUILDINGS

Pounds of steam figured per square foot of direct radiation per year, north of Richmond, Va.	500
Pounds of steam figured per cubic foot of net heated contents of building	5
Equivalent of 1 ton (2000 lb.) of run of mine bituminous coal	4 bbls. fuel oil 25,000 cu. ft. of natural gas.
Kilowatt-hour per day for elevators	Average 5 k.w.h. per car mile. Car miles per day in small buildings 5 and in large buildings 10 miles a day per elevator is the average.
Steam for heating domestic hot water	10 per cent of steam used for heating.
Kilowatt-hours per year of electric current for all purposes per square foot of total floor area	24 hour large buildings with Post Office, 2.5 8 hour large buildings without Post Office, 1.5 24 hour smaller buildings, 0.8

the cost of current from the central plant four cents per kilowatt-hour or more.

In arriving at the monthly consumption of steam the following table is used:

October	6%
November	10%
December	18%
January	18%
February	18%
March	15%
April	10%
May	5%

The average demand for steam per hour for heating and ventilating equals the annual consumption divided by 5000 (the number of hours in the average heating season).

The maximum demand for steam per hour for heating and ventilating is two and one-half times the average demand. This maximum demand figure divided by 30 gives the maximum boiler horsepower.

If the heating surface is known, the fan blast coils are reduced to the

equivalent of direct radiation by multiplying the square feet of heating surface in the fan blast coils by 3; and after all surface is reduced to equivalent direct steam radiation, to ascertain the total steam required per annum, the number of square feet of equivalent direct steam radiation is multiplied by 500. This is used as a check on the first assumption, and the mean of the two quantities is usually taken.

Indirect steam radiation (where no fan is used) is reduced to equivalent direct steam radiation by multiplying by 1½.

To reduce direct hot water to direct steam equivalent, it is divided by 1.6.

The average demand for electric power and light will be the total annual consumption divided by 8760, and the maximum demand will be two and one-half times the average demand in a 24 hour building and five times the average demand in an 8 hour building.

High grade 4-valve or una-flow engines are assumed to require 50 lb. of steam for each kilowatt-hour generated, on the switchboard, with 80 per cent allowance for the exhaust into the heating system. A rough check is to allow 5 lb. of coal for each kilowatt-hour generated. In the old style engine in common, use 70 lb. of steam per kilowatt-hour is a fair average.

To reduce the pounds of steam to coal, covering all losses in the plant, an average evaporation of 8 to 1 is assumed for bituminous coal in the larger plants, 7 to 1 in the smaller plants, and 6 to 1 for anthracite pea or buckwheat coal.

Roughly, 6/10 lb. of coal per cubic foot is required per year for heating the ordinary building, while in buildings containing electric generating plants 1 lb. of coal per cubic foot is approximately correct for all purposes. Roughly, the maximum electrical demand in the large buildings averages 6/10 k.w. per square foot of gross floor area.

For boiler room repairs allow $2.00 per horsepower nominal rating.

For engine room repairs allow $2.00 per annum per kilowatt total nominal rating of generator.

For boiler and engine room supplies allow $2.00 per annum per horsepower of boilers installed.

Boiler room labor averages $2.00 per ton of coal fired, based on an 8 hour shift and 48 hours per week.

Ash removal averages 1/5 of a cubic yard to each ton of coal burned and is estimated to cost $1.00 per cubic yard to remove it.

The labor in a Federal Building containing an electric generating plant will roughly average the same as the cost of the coal, supplies and repairs to the boilers and electric generators.

The fixed charges for machinery in a Federal Building are 3 per cent interest and 5 per cent depreciation per annum on engines, boilers, etc. while on buildings, tunnels, etc., 2 per cent depreciation per annum is allowed.

The annual dividend which must be earned by the ordinary isolated Federal plant in comparison with the purchase of current from a public utility company is 10 per cent on the cost of the Government plant.

PART II—VENTILATION

CHAPTER XXIII

MODERN STANDARDS OF VENTILATION AND MEASUREMENTS OF AIR QUALITY AND QUANTITY

General Requirements, Air Supply, Temperature, Recirculation, Testing Methods, Instruments, Physiological Effects, Human Comfort, Comfort Charts, Comfort Zone, Humidity and Comfort.

VENTILATION is the science that treats of air in relation to human comfort, health, and efficiency. A study of the science of ventilation is a study of the best methods of conditioning and handling air, and a study of the effect of that air on the human system. The test of good ventilation is the measure of health, comfort and efficiency derived from it.

In general the application of ventilation applies to spaces which are densely occupied by human beings, such as auditoriums and school rooms, to spaces in which atmospheric contamination or overheating would otherwise occur, as under certain industrial conditions, and to spaces in which a fixed and controlled air condition is required, as in certain manufacturing processes. It is the object of ventilation to provide and maintain the desired atmospheric conditions.

GENERAL REQUIREMENTS OF VENTILATION

In the present status of the art of ventilation it is no longer felt that the chemical composition of the air is the important factor, but that proper ventilation depends upon a number of other factors which may be stated as follows:

1. Air Supply.
2. Air Temperature.
3. Relative Humidity.
4. Air Motion.

} The four factors, in combination, are the bases of what is termed "Effective Temperature."

5. Air purity, in reference to its freedom from odors, dust, bacteria, toxic gases, and other objectionable matter.
6. Air Distribution, with reference to general distribution, air movement, and freedom from drafts.
7. Psychological effects.

Prepared especially for THE GUIDE by the following committee: D. D. Kimball, *chairman;* O. W. Armspach, A. C. Davis, F. R. Still, A. C. Willard, C. E. A. Winslow and C. P. Yaglou.

Air supply is not the all important factor in ventilation, but the amount of air to be supplied per person, or the number of air changes to be furnished for any particular space, may be considered the starting point, for the air supply may be used as a means to an end in providing the conditions desired.

AIR SUPPLY FOR VENTILATION

A comparatively small quantity of air supply is required to take care of the needs of the lungs. A large quantity of air is required to meet the needs of the outside of the body and to provide the heat control necessary for the maintenance of health and comfort. In order to provide the necessary air movement to maintain uniform temperature conditions, remove odors and provide comfort, in spaces of considerable occupancy, the delivery by the ventilating plant of the following quantities of air, have been general practice and Table 1 gives the quantities of air required on the basis of occupancy and air changes:

The laws of many States require 30 cu. ft. of air per minute per pupil in classrooms. At the instance of Investigators who feel that this may be unnecessary, studies of this subject are being made.

Table 1. Quantities of Air Required for Ventilation

Schools:	
Classrooms	30 cu. ft. of air per person per minute
Assembly rooms	15 to 25 " " " " " " "
Gymnasiums	12 changes per hour.
Picture Machine Booth	30 " " "
Dining rooms	12 to 20 " " "
Kitchens	20 to 60 " " "
Wardrobes and lockers	5 to 10 " " "
Toilet, Bath, etc.	10 to 20 " " "
Theatres:	
Seating spaces	30 cu. ft. of air per person per minute
Toilets, etc.	20 to 30 changes per hour.
Hotels:	
Assembly rooms	30 cu. ft. of air per person per minute
Dining rooms	10 to 20 changes per hour.
Kitchens and Laundries	20 to 60 " " "
Toilets and Service rooms	12 " " "
Hospitals:	
Wards	40 to 60 cu. ft. of air per person per minute
Dining rooms	12 changes per hour.
Toilets and Service rooms	12 to 20 " " "
Kitchens and Laundries	20 to 60 " " "

These quantities assume the introduction of air of proper quality and they may be subject to change as may be indicated by local or special conditions. Many other spaces will be found in which ventilation is required.

See Code of Minimum Requirements for the Heating and Ventilation of Buildings, adopted by A. S. H. & V. E. in 1925, also Chapters XXIV and XXV.

AIR TEMPERATURE

It has been the experience of accredited engineers that overheating is detrimental to the quality of ventilation, and more harmful to human beings, than any other one thing.

Dry bulb temperatures are customarily required as given in Chapter I under Inside Temperatures.

Methods of controlling air temperature in ventilating plants are discussed under Automatic Heat Control, Chapter XVI and Air Conditioning and Cooling, Chapter XXV.

Freedom from injurious substances, such as gases and fumes, may be of the utmost importance. These are handled usually by mechanical exhaust ventilation with effective distribution of inlets to the exhaust ducts. This phase of ventilation involves, in one way or another, nearly all of the other items. See Chapter XXXII Dust, Exhaust and Collecting Systems.

Relative humidity bears an intimate relationship to air supply and air temperature. These relations are described under Physiological Effects of Ventilation in this Chapter.

The effective temperature index fixes no limits for relative humidity. Two practical limits are 30 to 60 per cent, the lower to hold during the winter season and the higher in the summer.

Air motion is most important and is intimately associated with the temperature and humidity, all of which enter into the Comfort Zone term, which has been designated Effective Temperature; as discussed under Physiological Effects of Ventilation.

Air purity has to do with human health, both from the standpoint of freedom from dust and other suspended substances, and from the standpoint of freedom from bacteria and other infectious media carried along with the dirt in air. Methods of cleaning air are treated in Chapter XXIX.

Freedom from odors is often accomplished by plentiful air supply and efficient distribution. In special cases this may be facilitated by other means, among which are Ozone, treated in Chapter XXX of The Guide.

Air distribution is of the utmost importance, and is closely correlated with effective temperature. Chapter XXIV, Systems of Ventilation, has much to do with the effectiveness of air distribution, as also does Chapter XXVIII, Design and Construction of Air Ducts.

VENTILATION DESIGN

In the practical work of engineers who design mechanical ventilating systems, and of architects and owners who have to pass upon these systems, the one item which is the basis of all calculations and layouts, is the quantity of air to be handled by the ventilating system to produce the results desired. The functions of the air handled in connection with ventilated spaces are: (1) to supply the necessary oxygen for respiration, (2) to keep the dilution of objectionable substances down to the proper proportion, and (3) to maintain the proper effective air temperature. It has been estimated that an adult at rest will breathe 0.25 cu. ft. of air per minute and exhale 0.01 cu. ft. of CO in the same period, or at the rate of 0.6 cu. ft. per hour, thus removing about 5 per cent of the

oxygen from the air actually breathed. This does not necessarily indicate the effect on the air in the room occupied. The same air may be rebreathed for a limited time without apparent harmful effect. Air may be filtered, washed, cooled and recirculated with evident satisfaction.

The air handled by the ventilating system may consist entirely of air taken in from the outside or it may consist partly of new air and partly of recirculated air.

HEAT FROM OCCUPANTS, LIGHTS, EQUIPMENT

In a crowded place of assemblage the heat given off by the occupants, together with that given off by the lighting and power equipment, is usually more than the normal heat loss through the structure to the outside air, even in winter under cold climatic conditions. This means that in order to preserve an equilibrium of effective temperature the entering air must be cooler than the leaving air, so that the problem is usually one of cooling and ventilating, rather than of heating and ventilating.

A typical case for winter might show about 300 B.t.u. of body heat, plus 100 B.t.u. per person from light, etc., being given up to the building against about 200 B.t.u. heat loss from the building, per person per hour. This would mean that 200 B.t.u. per person must be carried away by the air. (See page 60, Chapter I.)

If the flow of air is upward, or from the side, so as to bring the incoming air into direct contact with the occupants, the temperature of the incoming air should not be more than 5 deg. below the temperature of the air leaving the occupant, otherwise the conditions will be drafty and uncomfortable. Where the air is admitted through the ceiling, and the ceiling is high, the temperature difference may be slightly increased and, in some cases, the air quantity may be slightly decreased.

If a room is crowded in weather of 85 deg. outside temperature, with relative humidity of 70 per cent while giving each occupant 30 cu. ft. of air per minute, it may be assumed, that there will be an increase of temperature of at least 5 deg., due to body heat and heat from equipment. The moisture increase, from the bodies of the occupants, may be assumed as 10 grains per minute, or 0.30 grains per cubic foot of air handled.

Under such a condition some method of air cooling will be needed to obtain satisfactory ventilation. A good air washer may reduce the temperature of the air passing through it about 70 per cent of the difference between the wet and the dry bulb temperatures. Its operation would hardly be worth while without a water supply of 50 deg. temperature or less because of increasing relative humidity with a decreasing temperature. The beneficial effect of an air washer will increase in proportion as the relative humidity of the outside air is lower.

It will be understood that the example cited is an extreme case of temperature and humidity.

Experience, however, shows that a supply of fresh air which proves to be adequate for maintaining a desirable effective temperature in winter will prove inadequate for the same purpose in hot weather. While an increased volume of air supply is often of material benefit, the use of

refrigeration brings the final hot weather solution, not so much in actual temperature drop as in humidity control.

When using an upward system of air supply, as through floor mushrooms, drafts will be felt with the introduction of air at temperatures of more than 5 deg. cooler than the average room temperature. For this reason, and for the additional reasons of sanitation and control, the downward system of ventilation is perhaps more efficacious in large and intensively occupied places of assemblage. The air should be brought in at a point high enough to permit of its being diffused before coming into contact with the occupants.

RECIRCULATION

Where recirculation of air in ventilation work is utilized care should be taken that the recirculated air is suitable. In many cases it must be reconditioned by cleaning, dehumidifying and deodorizing. The saving in operating costs obtainable by recirculation of the air in ventilation systems, while very considerable, must not be obtained at the expense of quality. A reduction in the quality of the ventilation when recirculation is used can be prevented by the installation and use of complete mechanical ventilation equipment available for this purpose.

The percentage of recirculated air may be varied to suit the seasonal changes so as to conserve heat in winter and refrigeration in summer, but at no time should the recirculated air exceed 75 per cent of the total air supply.

Toilets and similar rooms, in buildings using recirculation, should be separately, mechanically ventilated, with the exhaust in excess of the supply, in order to prevent objectionable odors from diffusing into other parts of the building.

PSYCHOLOGICAL AND PHYSIOLOGICAL REACTIONS

The engineer who disregards the psychological factor in ventilation is indeed short sighted. As in most human contacts and activities, the effect on the mind of air conditions is profound.

Consideration must always be given to the elimination of objectionable noise from machinery and to air friction noises. It is usually helpful if the occupants of a ventilated room may visualize some indication that air is moving. It helps if they may, when they wish, place their bodies or portions thereof, in sensible air currents, to demonstrate that ventilation is in effect. Periodical or occasional temperature reductions, or increases in air movement, possibly accompanied by muscular exercises, are of great value, psychologically as well as physically.

After a good ventilating system is designed the engineer is only fairly well started on the road to good ventilation. A system is not a ventilating system until it ventilates. Here is where the operating man and proper supervision of operation come in. It is recommended that the engineer who designs a ventilation plant should supervise its installation, and that his interest and responsibility should be maintained during the operation of the plant.

It is a familiar fact that a room may be comfortable at one temperature and yet decidedly uncomfortable at another time at the same dry bulb temperature. This fact may be due either to a change of relative humidity or to air motion. On the other hand a room may feel equally comfortable with different dry bulb temperatures provided the relative humidity or air motion is varied to produce this effect, Other factors enter into this problem, such as changes of clothing (seasonal or otherwise), acclimatization, degree of activity, etc.

The prolonged effect of temperature, humidity and air motion upon health is not so well understood as their effect upon comfort. Strictly speaking good ventilation is merely a relative term, but today ventilation is considered necessary for personal comfort and for good health. These reactions are further discussed under Physiological Effects of Ventilation in this Chapter.

TESTING METHODS AND APPARATA

Temperatures

In the measuring of room temperatures care must be exercised to prevent the results from being affected, by the body heat of the observer, by drafts from doors, windows and other openings or by radiant heat from some local source such as a radiator, a wall, etc. All thermometers should be mercury thermometers with engraved stems. The total graduations of the thermometers should be from 20 to 120 deg. fahr., in one degree graduations. No ten degrees should occupy a space of less than ½ in. The accuracy throughout the whole scale must be within one-half degree. The operator should take hold of the top and no part of the body, including the hand, should be nearer than 10 in. to the bulb. The thermometer should not be closer than 5 ft. to any door, window, or other opening; should not be closer than 12 in. to any wall, and should be between 4 and 6 ft. from the floor. A sling instrument should be used for extreme accuracy.

For measuring duct temperatures an angle duct thermometer should be used, having a flange to bolt on the side of the duct, with the bolt extending into the duct at least 6 in.

Recording thermometers, generally have considerable lag and should not be used for the taking of temperatures for testing, but rather for giving continuous records of the operation of the plant, as the charts will indicate any lack of attention on the part of those responsible for the operation of the plant.

Humidity

The sling psychrometer is the recognized standard instrument for determining humidities. In order to obtain accurate readings considerable skill is required on the part of the operator. The wicking must be clean, distilled water should be used, and the temperature of the water should be slightly above the wet bulb temperature of the surrounding air.

The psychrometer should be swung rapidly and two or three observations should be made to see that the wet bulb temperature has gotten to a point where it is stationary before the final reading is noted. Errors

in reading wet and dry bulb thermometers are usually because of not obtaining a complete depression of the wet bulb temperature.

The standard dry and wet bulb tables giving the relative humidity should be used with sling psychrometer readings.

In taking humidity readings in ducts it is practically impossible to use a sling psychrometer. For this work the stationary hygrodeik arranged for bolting on to the side of the ducts, with two bolts extending into the ducts, will be found very convenient. Due to the velocity of the air passing over the bolts within the ducts an accurate reading will be secured, corresponding to those given by the sling psychrometer.

CO_2 Determinations

The amount of carbon dioxide in the air, while not a harmful element, is a convenient index of the rate of air supply, or of the frequency of air change in an occupied room, and of the distribution of the air within large rooms. A high carbon dioxide value indicates air stagnation and liability to stale odors and overheating.

The Peterson-Palmquist apparatus has been generally accepted as the standard device for the determination of carbon dioxide in air investigations. The principle involved is the measurement of a given volume of air, the absorption of the contained carbon dioxide in a caustic potash solution, and the re-measurement of the volume of air at the original pressure in a finely graduated capillary tube, the difference in volume representing the absorbed carbon dioxide. See Report of Committee on Standard Methods for Examination of Air, *American Public Health Association*, Vol. 7, No. 1 *American Journal of Public Health*, Jan., 1917.)

Where field conditions are such that this apparatus may not be conveniently used, as in street cars, the laboratory method is recommended.

Dust

Atmospheric dust becomes of great importance in certain industrial processes, and if the dust be siliceous in nature the hazard to health may be very serious.

The Hill Dust Counter is a simple device with which to measure the number of very large particles of dust in the air, while more exact studies of dust may be made with the Konimeter, or with the Impinger. (See Public Health Bulletin No. 144, 1925, U. S. Public Health Service.)

Bacteria

The number of bacteria which are attached to heavy particles of dust or drops of moisture may be determined by the number of colonies that develop on a culture plate which has been exposed for two minutes. A standard 4 in. Petrie dish, with agar-agar for a media, is used for this purpose. The plates are incubated from 24 to 48 hours at a temperature of 98 deg. fahr. At the end of this time the separate colonies have developed to a size which are easily counted. If an incubator is not available, cultures may be grown at room temperatures (70 deg.) for a period of five days.

The number of bacteria actually present in the air may be determined by the use of the Wallace and Tiernan Sampling Pump or the Impinger, with subsequent plating.

VOLUMETRIC AIR MEASUREMENTS

Volumetric air measurements must be made with skill and precision and great care must be taken in securing the right conditions under which such measurements are made. There are two general methods in use for measuring air volumes, the first being the anemometer method, and the second, by means of determining the kinetic energy of the moving air current by the use of suitable U-gages containing a fluid (known as the Pitot tube method). The use of these two methods is described in Chapter XXXIV.

While the anemometers give the air velocities directly, the kinetic measurements of the air current require specially constructed gages, tubes, etc. Generally speaking, it will require considerable more skill to take volumetric air measurements by means of the latter method, whereas the anemometer method can be used fairly accurately after a short experience.

ANEMOMETERS

The ordinary anemometers should be used for the lower velocities only, the maximum range being considered as from 2 to 20 ft. per second.

In testing the air flow in a large ventilating plant a preliminary measurement should first be made as to secure a general knowledge of the air distribution. Before preliminary readings are taken all dampers and registers should be opened. Preliminary readings can be made by holding the anemometer 2 in. from the register face or grille and going slowly back and forth over the entire area of the register for one-half minute's time. The amount of air should be computed for the entire area travelled by the anemometer, no deduction being made for the metal of the register itself.

After preliminary readings and adjustments, the final readings should be taken. The registers or openings should then be proportioned off in about 8 in. squares and a reading taken on each square, the average of velocities to be taken as the average air velocity through the register or grille.

Where exterior diffusers are used, the average velocity should be determined by placing over the diffuser a suitable cellar of not less than four times the length of the distance that the diffuser extends beyond the wall face and readings taken as above described for registers.

The time for taking readings should be not less than one-half minute for the preliminary measurements and as much time as is required to secure accurate readings for the final measurements.

Anemometers should be calibrated frequently as to their accuracy under the varying velocities, and all readings should be corrected in accordance with the calibration curve for the particular instrument used.

(See Report on Measuring Air Velocities with the Anemometer, with discussion, AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS TRANSACTIONS 1913, Vol. 19, pp. 202 to 207.)

PITOT TUBES

Measurements of air velocities exceeding 20 ft. per second should be made by means of pitot tubes. Volumetric determinations from pitot

tube readings must take into account the barometric pressure, temperature, humidity, and the possible dust of the air. These factors determine the weight or density of the air.

In general, no accurate velocity pressure readings can be taken of any air current which is affected by changes of directions of the ducts. Accurate readings can only be taken in a duct which is straight and without turns and elbows for a distance of at least 50 times the diameter of the circular duct, or the greatest dimension of a rectangular duct. Where space conditions do not make such conditions possible, baffling or dividing the duct into numerous smaller ducts by division plates becomes necessary. Pressure conditions must be determined over the entire area in the drawings of duct traverses as taken from the Standard Code for Testing Centrifugal and Disc Fans of the AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS and the *National Association of Fan Manufacturers*.

For determining the velocity of moving air current in ventilating ducts standard tables of velocity pressures will assist in giving quick but approximate results.

Where greater accuracy is desired the density of the air must be determined and the pitot tube readings must be converted into velocities.

The velocities corresponding to the velocity pressure readings should be averaged to obtain the average velocity for each traverse. Average velocity pressures should be calculated from the average velocities thus determined.

$$V = 1096.2\sqrt{\frac{P_v}{W}}$$

V = velocity in feet per minute.
P_v = velocity pressure in inches of water.

For dry air at 70 deg. and a barometric pressure of 29.92 in. the formula becomes:

$$V = 4005\sqrt{P_v}$$

Gages or Manometers

In view of the fact that the velocity pressure exerted by *moving* air in ordinary duct systems is very slight, frequently going below 1/1000 in. of water, the most accurate gages for measuring these low pressures must be used. For all such measurements gasoline, benzine, or preferably alcohol should be used, with levels for setting the instrument horizontal in both directions. The instruments must be placed upon a firm support to avoid vibration. The tube should be inclined for accurate measurements on low velocities about 1 to 50, and even 1 to 100 may become necessary where extreme accuracy at low velocities is desired. With care it is possible to read with accuracy very nearly 1/100 in. of water.

(See Report on the use of the Pitot Tube, AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS TRANSACTIONS 1914, Vol. 20, p. 211, and Standard Code for the testing of Centrifugal and Disc Fans, AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS TRANSACTIONS 1923, Vol. 29, pp. 407 to 416.) Also Chapter XXXIV of THE GUIDE.

AIR MOVEMENT DETERMINATIONS

Temperature, humidity and volume of air supply or exhaust do not appear to be the only determining factors of atmospheric comfort. Air movement is a vital factor in the prevention of stagnant areas and bodily discomfort. Where a determination of air movement is desirable the Kata thermometer, as developed by Dr. Leonard Hill, of England, may be used. (See Report of Committee on Standard Methods for Examination of Air, *American Public Health Association, American Journal of Public Health*, Vol. 7, No. 1, January, 1917. The wet Kata-thermometer gives the rate of cooling by radiation, convection and evaporation. The dry Kata-thermometer gives the rate of cooling by radiation and convection. The difference between the two is the rate of heat loss due solely to evaporation. Air movement is a consideration in the determination of the effective temperature.

Air movement may be approximately determined by observation of the movement of a smoke cloud and the use of a stop watch, the smoke cloud being formed by means of an ammonium cloud device, or by a smoke bomb. Carefully balanced gas balloons may also be used.

The synthetic air chart devised by Dr. E. Vernon Hill, and revised on the basis of investigations by the Society's Research Laboratory has been frequently used as a means of graphically recording the measurements of air conditions as found. This will be found fully described in Chapter XXXIV. (For original of this chart see also Ventilation Standards and the Synthetic Air Chart, TRANSACTIONS 1917, Vol. 23, pp. 607 to 628.)

The weighting given to the different factors for which provision is made therein may be subject to modification and to the experienced judgment of the Engineer. Obviously weightings of these factors as given for a school room may not do for an industrial plant, garages, etc.

As more becomes known about the physiologic effects and the threshold concentrations of various kinds of dusts, gases, bacteria, and odors, it may be able to more definitely determine the characteristics of such a chart as may be more generally useful and acceptable.

PHYSIOLOGICAL EFFECTS OF VENTILATION[1]

THE atmospheric condition of space for human occupancy should be based upon the relation and effect of the various factors entering into the well being of the individual as regards his physiological reaction, feeling of comfort, psychological reaction, and morale. A person's well being may be positively improved, unaffected, or positively harmed by the condition of the air with which he is surrounded. Whether satisfactory ventilation demands only a condition which is not positively harmful or whether it demands a condition which is positively beneficial depends upon one's point of view.

To the public health official charged with inspection of sanitary conditions in industrial plants it is usually sufficient that the condition of the air be not a positive menace to the health of workers. To the efficiency expert and to the engineer in charge of designing equipment for conditioning air for schools and audience halls, it is desirable to produce a condition which is positively beneficial to comfort, health, and morale. To the management of places of amusement it is decidedly advantageous to produce a condition of maximum comfort. This difference in point of view is no doubt responsible for much of the difference of opinion in regard to proper atmospheric conditions.

[1]Prepared by F. C. Houghten.

The factors which may affect a person's health, comfort, or well being are: (1) temperature, (2) humidity, (3) motion of the air, (4) dustiness, (5) bacteria content, (6) odors present, (7) other injurious substances.

The first three factors taken together determine a person's feeling of warmth and influence elimination of body heat. As such, they are the three most important factors in the physiological effects of the surrounding atmosphere. Besides their combined effect on heat elimination from the body and one's sense of warmth, moisture content and motion of the air may otherwise affect a person's well being.

Dust, bacteria, and odors may be of less importance when compared with the combined effect of temperature, humidity, and air motion but they are nevertheless important factors, and must be given consideration.

HOW TEMPERATURE, HUMIDITY, AND AIR MOTION AFFECT HUMAN COMFORT

A person's feeling of warmth is not due alone to the temperature of the surrounding air as registered by a dry bulb thermometer; neither does it depend solely upon the temperature indicated by a wet bulb thermometer. Dry air at a relatively high temperature may feel cooler than air of considerably lower temperature with a high moisture content.

Air motion makes any moderate condition feel cooler.

Human comfort or discomfort, as regards feeling of warmth, depends largely upon the body temperature, and, therefore, upon the relation between the rate of production and dissipation of heat. By the process of metabolism heat is constantly generated within the body, which heat must be eliminated from the surface of the body and the respiratory tract by radiation, convection and evaporation. To maintain a constant body temperature the heat loss must equal the heat produced. It is, therefore, apparent that any interference with the elimination of heat from the body is accompanied by a rise in temperature and a feeling of discomfort.

There are three principal factors affecting loss of body heat: (1) temperature, (2) humidity, (3) air motion.

As the temperature of the air and surrounding objects rises, the loss of heat by convection and radiation decreases. When the air temperature reaches that of the body, the loss by radiation and convection ceases. Finally as the air temperature exceeds that of the body, heat is transferred from the air to the body.

As the temperature of the air rises and heat loss by radiation and convection decreases, the body endeavors to maintain temperature equilibrium by making available more perspiration and a resulting greater heat loss by evaporation.

From the above, it is concluded that there must necessarily exist certain

combinations of temperatures and humidities, which produce the same total body heat loss by radiation, convection, and evaporation and therefore the same feeling of comfort or discomfort. Lines passing through such air conditions plotted as a psychrometric chart may be called equal

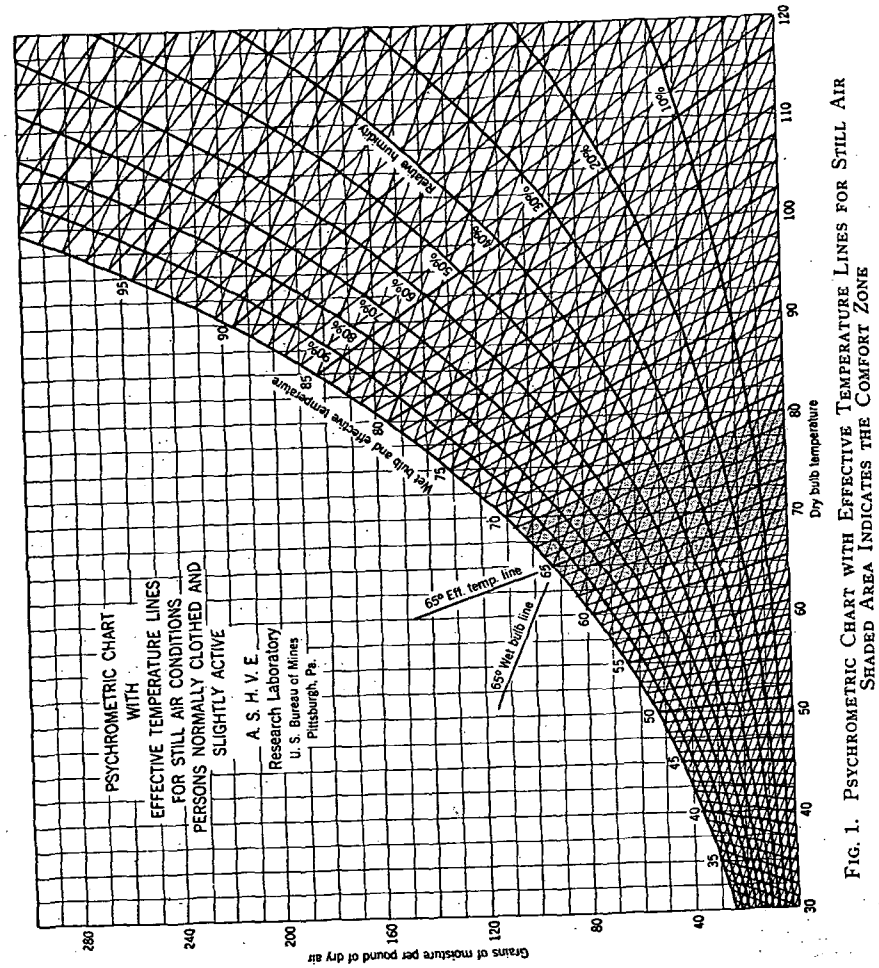


FIG. 1. PSYCHROMETRIC CHART WITH EFFECTIVE TEMPERATURE LINES FOR STILL AIR SHADED AREA INDICATES THE COMFORT ZONE

comfort lines. The fact is further substantiated by the general experience of heating engineers in observing that the lower the humidity the higher the dry bulb temperature required for the same degree of comfort.

A series of tests have been made in the two psychrometric rooms of the Research Laboratory of the AMERICAN SOCIETY OF HEATING AND

VENTILATING ENGINEERS, *in order to locate these lines on the psychrometric chart. Complete reports of these studies for both still and moving air are reported in the Society's* TRANSACTIONS, Vol. 27-32 inclusive, and in the JOURNALS for 1926 and 1928.

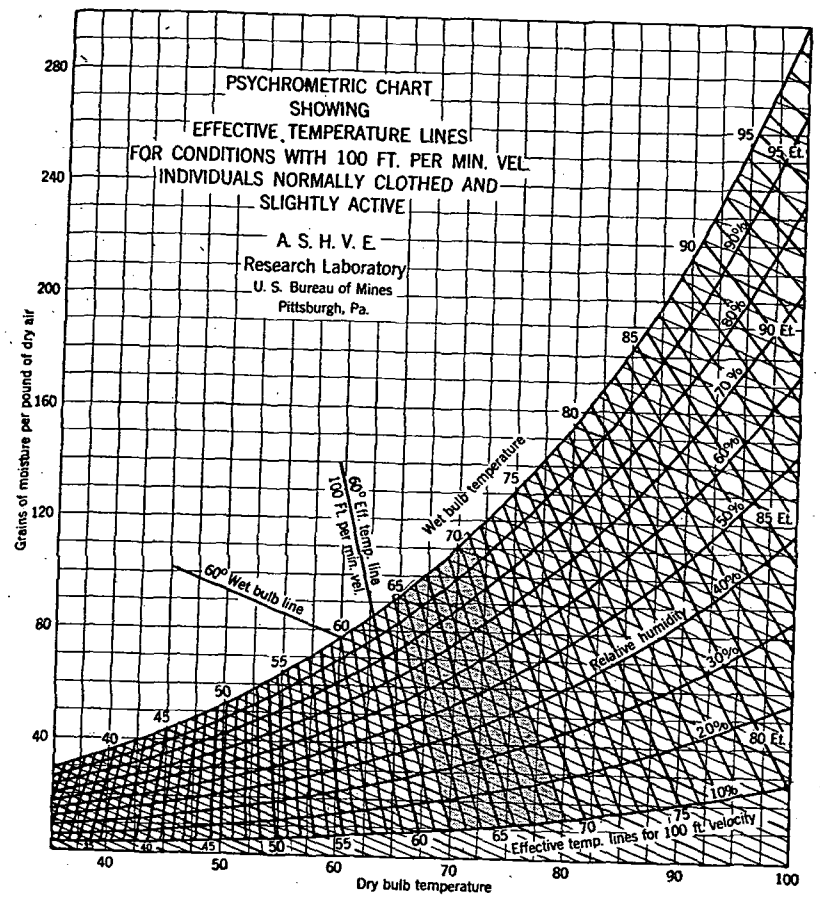


FIG. 2. PSYCHROMETRIC CHART WITH EFFECTIVE TEMPERATURE LINES FOR 100 FT. AIR VELOCITY. SHADED AREA INDICATES THE COMFORT ZONE

The relation of temperature and humidity to comfort for persons normally clothed and at rest in still air, is given in Fig. 1, while the effect of air motion upon comfort or effective temperature for persons normally clothed is given in Figs. 2, 3 and 4.

HOW TO USE THE COMFORT CHARTS

In the Psychrometric Chart, Fig. 1, dry bulb temperature is plotted as abscissae and grains of moisture per pound of dry air as ordinates. The maximum moisture which the air can hold at various temperatures

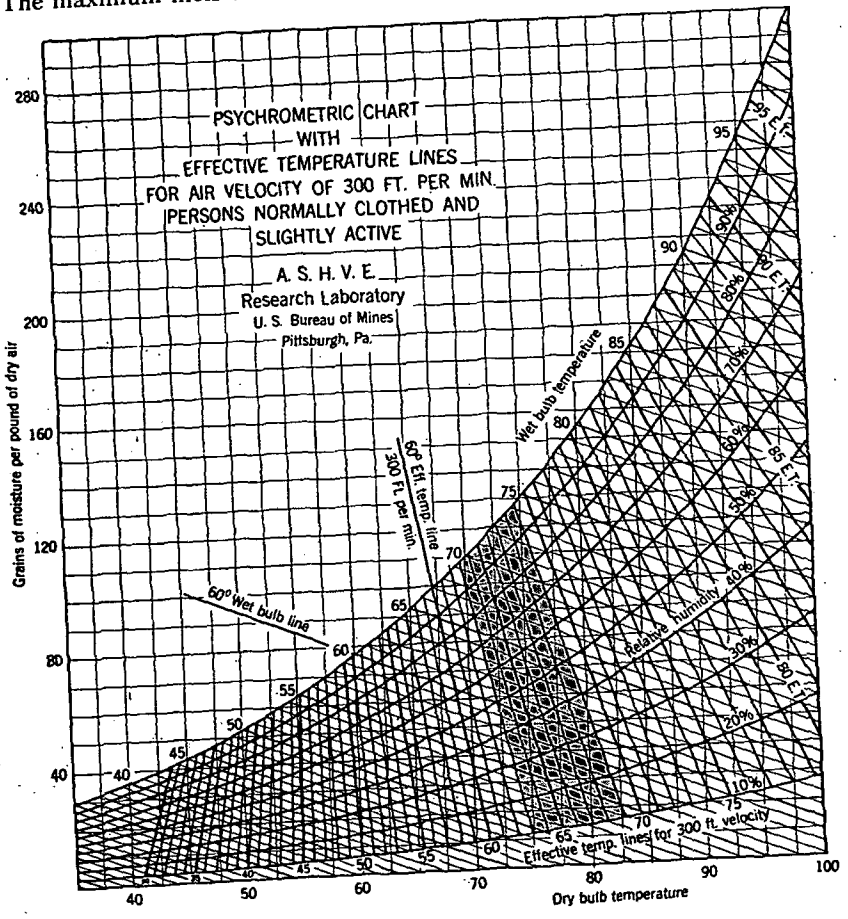


Fig. 3. Psychrometric Chart with Effective Temperature Lines for 300 ft. Air Velocity. Shaded Area Indicates the Comfort Zone

gives the saturation, or 100 per cent relative humidity curve. Relative humidities between 0 and 100 per cent are given by a series of curved lines similar to the saturation curve. The wet bulb temperatures for all atmospheric conditions are given by a series of nearly parallel oblique

lines. Effective temperature is given by a series of oblique but not parallel lines which approach being parallel to the wet bulb lines at high temperatures and humidities, and to the dry bulb lines at low temperatures. The numerical values of the wet bulb and effective temperature lines are given by the dry bulb temperatures at their intersection with the saturation curve.

Dry bulb temperature is the temperature of the air as determined by an ordinary dry bulb mercury thermometer.

Wet bulb temperature is the temperature as determined by a similar thermometer, except with its bulb encased in a fine mesh fabric bag moistened with clean water and whirled through the air until the temperature depression due to the cooling effect of evaporation from the moistened bag reaches equilibrium.

The conditions of comfort as shown by these charts are primarily for winter time conditions in relatively cold climates, and what is hereinafter said relative to these charts pertains to such conditions. The conditions of indoor comfort corresponding to summer time conditions or to conditions in the warmer climates are somewhat different. For data pertaining to this subject see Inside Temperatures, Chapter I, pp. 4.

Wet bulb temperature corresponds to that which a thoroughly wet body will attain if the air passes over it for a sufficient length of time and with a high enough velocity. A person's body is not thoroughly wet and hence does not react entirely in accordance with either the dry or the wet bulb temperature. At high temperatures when the body is moist with perspiration, it reacts more nearly in accordance with wet bulb temperature while at low temperatures when the body is comparatively dry it reacts more nearly in accordance with the dry bulb temperature.

Effective temperature is an experimentally determined scale which unlike the dry bulb and wet bulb scales is a true measure or index of a person's feeling of warmth in all combinations of temperature, humidity, and air motion. In other words, for any one given effective temperature a person will feel the same degree of warmth or coldness regardless of the dry bulb temperature, wet bulb temperature and velocity of the air, required to produce that particular effective temperature.

The psychrometric charts for moving air, Figs. 2, 3 and 4 differ from the chart for still air (Fig. 1) only in that the effective temperature lines for any particular degree do not intersect the dry bulb, wet bulb or dew-point temperature lines at the same degree on the saturation or 100 per cent relative humidity curve but are removed to the right so that the effective temperature for any dry and wet bulb temperature is lower for moving air than it is for still air. This difference between the effective temperature for still air and for moving air, of any velocity, is the cooling resulting from that velocity. The difference between the dry or wet bulb temperature and the effective temperature at saturation also gives the cooling produced by the velocity for that condition.

The psychrometric chart (Fig. 5) gives the effective temperature lines for still air and for three velocities ranging from 150 to 500 ft. per minute on the same chart. It is of value in giving at a glance the relative cooling effect of different velocities.

THE COMFORT LINE AND THE COMFORT ZONE

That range of effective temperatures over which 50 per cent of people feel comfortable, namely 62 to 69 deg. fahr. is called the Comfort Zone.

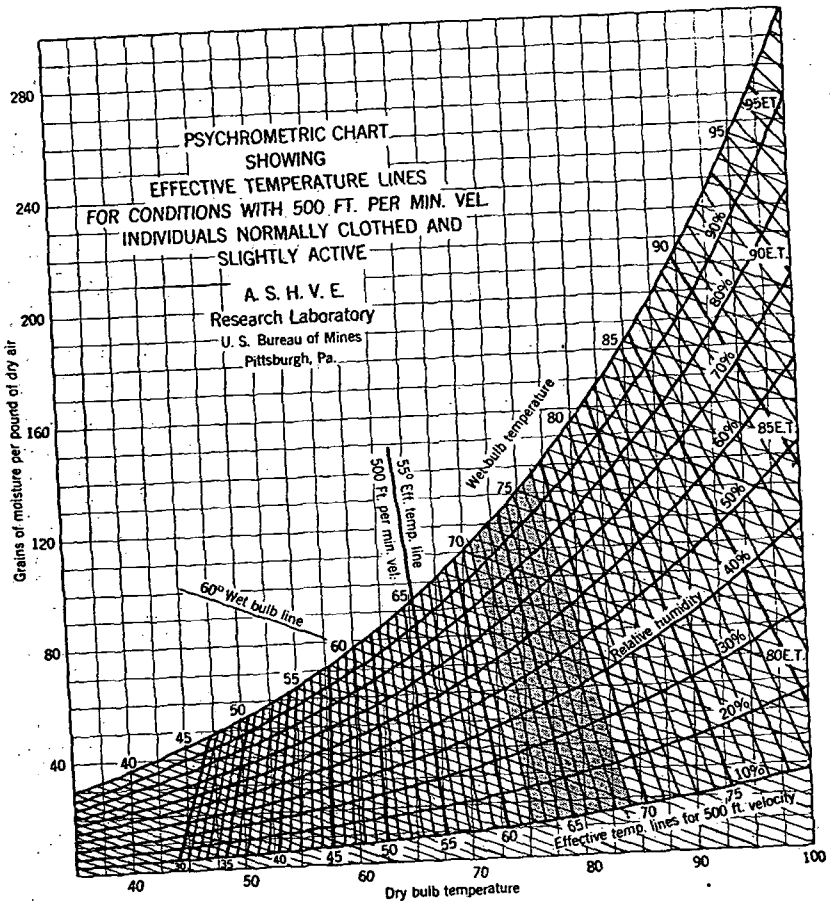


FIG. 4. PSYCHROMETRIC CHART WITH EFFECTIVE TEMPERATURE LINES FOR 500 FT. AIR VELOCITY. SHADED AREA INDICATES THE COMFORT ZONE

That particular effective temperature at which a maximum number of people feel comfortable is called the comfort line. While at rest, 97 per cent of people have been found to be comfortable at 64 deg. fahr. effective

temperature. Persons working at various rates are most comfortable at effective temperatures below 64 deg. The exact effective temperature giving maximum comfort for persons working at various rates have not yet been determined by the Research Laboratory but from the best data available, they are as follows: At rest, 64 deg.; Light work, 62 deg.; Hard work, 60 deg.

The data given in the charts, Figs. 1 to 5 are for persons normally clothed and differ somewhat from the data contained in earlier editions of THE GUIDE which data were for persons stripped to the waist.

HEAT DISSIPATED TO THE ATMOSPHERE FROM THE HUMAN BODY

The heat dissipated from the human body is a factor which must be taken into consideration in conditioning air in audience halls. Research at the Laboratory of the AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS[2] shows that the total heat dissipated from the body of an individual does not vary greatly over the temperature range usually met with in air conditioning and is a function of Effective Temperature. The relative proportion of this total heat loss dissipated as latent heat (heat of evaporation of perspiration) and sensible heat (heat loss by radiation and convection) does, however, vary greatly over this temperature range and is for all practical purposes a function of dry bulb temperature. The curve, Fig. 6, gives the total heat loss in B.t.u. per hour for an average person for different effective temperatures. The percentages of the total heat loss dissipated as latent and sensible heat are plotted against dry bulb temperature in Fig. 7.

An atmospheric condition resulting in sensible perspiration is to be avoided for good air conditions. Table 2 gives the approximate effective temperature at which perspiration is noticeable in different degrees by most individuals for 95 per cent and 20 per cent relative humidity.

(*A*) How much sensible heat, how much latent heat, and how many pounds of water vapor will be added to the atmosphere of an auditorium per hour by an audience of 1000 adults, when the dry and wet bulb temperatures are 75 and 63.5 deg. fahr. respectively.

(*B*) If the dry and wet bulb temperatures of the auditorium were 85 deg. and 63 deg. respectively, how much heat and moisture would be dissipated to the atmosphere?

(*C*) From Fig. 1 find the effective temperature of the atmospheric condition to be 70.3 deg. and from the curve, Fig. 6 find the total heat loss for this effective temperature to be 403 B.t.u. per hour for an average person. This curve Fig. 7 shows the sensible and latent heat loss at 75 deg. dry bulb to be 69.0 per cent and 31.0 per cent respectively. The sensible heat added per hour by the audience is $0.69 \times 403 \times 1000 = 278{,}070$ B.t.u. The latent heat added per hour is $0.31 \times 403 \times 1000 = 124{,}930$ B.t.u. The weight of water vapor added to the atmosphere per hour is given by the latent heat loss divided by the latent heat of evaporation at body temperature or $\frac{124{,}930}{1036} = 120.6$ lb.

(*D*) The wet and dry bulb temperatures of 85 and 63 deg. respectively will give an effective temperature of 74.9 deg., and a total heat loss of 401 B.t.u. per hour per person. The sensible heat added to the atmosphere will be $0.45 \times 401 \times 1000 = 180{,}450$ B.t.u. per hour and the latent heat added will be $0.55 \times 401 \times 1000 = 220{,}550$ B.t.u. per hour. The water vapor added to the atmosphere of the auditorium will be $\frac{220{,}550}{1036} = 212.9$ lb. per hour.

[2]Will be published in future issues of the JOURNAL of the AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS.

The above examples demonstrate that while the effective temperature and hence the feeling of warmth and rate of total heat loss does not differ greatly in the two cases the relative proportion of sensible and latent heat loss is reversed. In order to maintain the air conditions stipulated the air conditioning equipment must remove 54.1 per cent more sensible heat in (*A*) than in (*B*); and 76.5 per cent more latent heat or water vapor in (*B*) than in (*A*). In (*A*) 69 per cent of the total heat loss is sensible while in (*B*) only 45 per cent of the total loss is sensible.

CONDITIONING AIR FOR HUMAN COMFORT

There are four fundamental ways of producing effective cooling: (1) The dry bulb temperature may be lowered by direct cooling or removal of heat. (2) The moisture content of the air may be reduced. (3) Air motion may produce effective cooling except for extremely severe conditions. (4) Evaporation of water without addition or subtraction of heat is accompanied by an increase in moisture content and a fall in dry bulb temperature along the wet bulb line resulting in effective cooling.

Take as an example a condition of 92 deg. dry bulb and 40 per cent relative humidity having a wet bulb temperature of 72.8 deg. and effective temperature of 81.1 deg. This condition can be made equivalent to 78 deg. effective temperature or it can be made to feel 3.1 effective deg. cooler by any one of the four fundamental changes mentioned.

(1) By the removal of heat the dry bulb may be made to fall to 85.5 deg. (see Fig. 1) along the "*90 grain moisture per pound of dry air*" *or 64.2 deg. dew-point line when* the effective temperature will be 78 deg.

(2) Without removal of sensible heat or lowering of the dry bulb, the moisture content may be reduced from 90 to 44 grains per pound of dry air, when the effective temperature will be 78 deg.

(3) A 500 ft. velocity (see Fig. 4) will change the still air condition of 81.1 deg. effective temperature to 78 deg. Effective Temperature or will give 3.1 deg. Effective Temperature cooling.

(4) Evaporation of water at room temperature without addition or removal of heat will cause the point on the chart, Fig. 1, indicated by our condition, to move along the wet bulb line to the left thereby lowering the dry bulb temperature and increasing the moisture content. The wet bulb temperature will remain the same but the effective temperature will be lowered. By adding 14 grains of moisture without heat, the dry bulb will fall to 83.8 deg. and the effective temperature will fall to 78 deg.

The best method of producing effective cooling to be employed in any particular case will depend upon accompanying circumstances and should be determined by a competent engineer. Generally, the removal of heat or water vapor or both, by direct cooling or dehumidifying is most effective. Effective cooling by air motion or evaporation of water is relatively much less expensive, but these methods of cooling are limited to certain conditions of temperature and humidity. Cooling by evaporation of water is effective when the air is dry or when there is considerable difference between the wet and dry bulb temperature. Cooling by air motion is most effective at low temperatures. When the effective temperature approaches that of the body little or no cooling results and for certain higher temperatures air motion will make an uncomfortable condition even less bearable.

For moderately high temperatures greater effective cooling is ex-

perienced as the result of air motion at high humidities than at low humidities. This suggests a valuable method of cooling by a combination of evaporation and air motion. Take, for example, a condition of 96 deg.

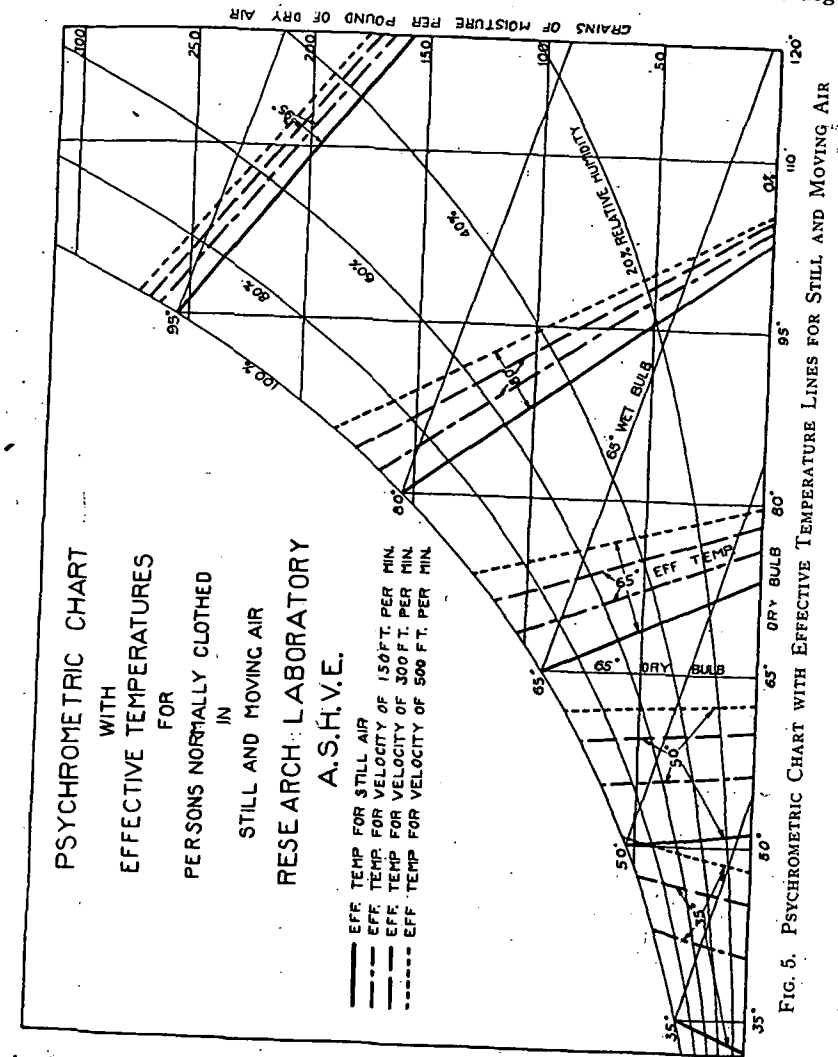


FIG. 5. PSYCHROMETRIC CHART WITH EFFECTIVE TEMPERATURE LINES FOR STILL AND MOVING AIR

dry bulb and 80 deg. wet bulb having an effective temperature of 85.7 deg. A 300 ft. air velocity will improve this condition by only 2.2 deg. Saturation with water vapor will give a condition of 80 deg. dry bulb, 80 deg. wet bulb and 80 deg. effective temperature or 5.7 deg. effective tempera-

ture improvement. A 300 ft. air velocity with this new wet and dry bulb will give an effective temperature of 75.7 deg. or a total improvement of 10.0 deg.

For cooling produced by velocities other than those given in Figs. 2, 3 and 4 the reader is referred to the Tables and Examples on page 737 of the November 1926 JOURNAL.

Example 1.—Given dry bulb and wet bulb temperature of 75 and 68 deg. First: what is the effective temperature? Second: is this condition warmer or cooler than 80 deg. dry bulb and 60 deg. wet bulb?

Answer.—The first condition is given by the intersection of the 75 deg. dry bulb line and the 68 deg. wet bulb line. The effective temperature is given by the numerical

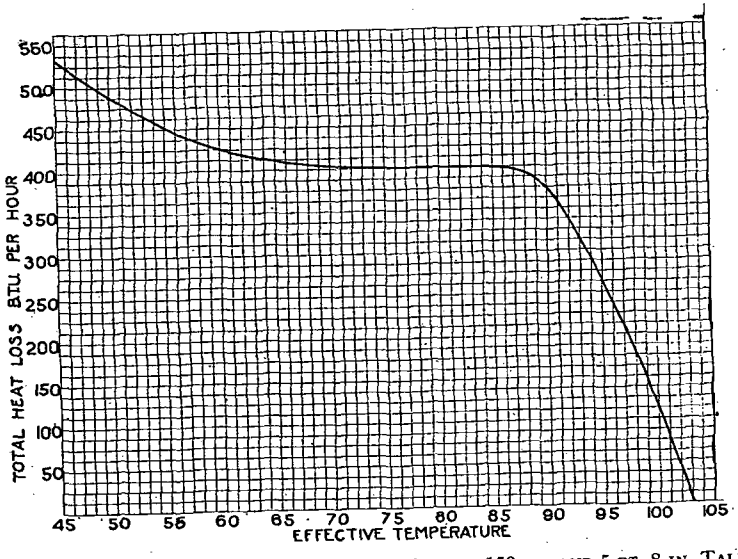


FIG. 6. TOTAL HEAT LOSS FOR AVERAGE MAN OF 150 LB. AND 5 FT. 8 IN. TALL

value of the effective temperature line, passing through this point and indicated by the scale along the saturation curve, and is 71.9 deg. effective temperature. The second condition is given by the intersection of 80 deg. dry bulb and 60 deg. wet bulb and is 71.7 deg. effective temperature. It is therefore 0.2 deg. effective temperature cooler than the first condition.

Example 2.—Given 76 deg. dry bulb and 61 deg. wet bulb how many degrees difference between this condition and the comfort line or 64 deg. effective temperature?

Answer.—The effective temperature of this condition is given by the intersection of the 76 deg. dry bulb and 61 deg. wet bulb lines and is 70 deg. effective temperature or 6 deg. effective temperature warmer than the comfort line.

Example 3.—Given the dry and wet bulb temperatures in a room 76 and 54 deg. respectively, what air velocity will be necessary to make this condition ideally comfortable, that is, 64 deg. effective temperature?

Answer.—From Fig. 1 for still air it will be seen that this condition has an effective temperature of 68.1 deg. in still air, while an air velocity of 300 ft. (see Fig. 3) gives an effective temperature of 64.7 deg. A velocity of something more than 300 ft. per minute

will give the desired result. The exact velocity may be found by looking through the various tables 2 to 7, for *moving* air, in the JOURNAL OF THE AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS, November 1926.

Example 4.—Given a condition having dry and wet bulb temperature of 90 and 85 deg. respectively, how much cooler will this condition feel if 300 ft. air velocity is supplied instead of still air?

Answer.—From Fig. 1 it will be found that this condition in still air has an effective temperature of 86.6 deg., while if the air has 300 ft. velocity it will be found from Fig. 3 that it will have an effective temperature of 83.8 deg. Cooling of 2.8 deg. will be produced by the 300 ft. air velocity.

There are many applications for these data. In warm weather it is especially desirable to have greater comfort in school rooms, theaters,

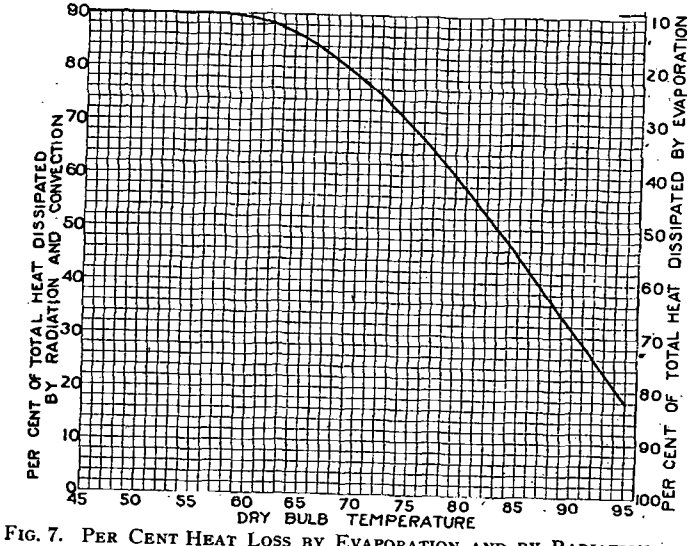


FIG. 7. PER CENT HEAT LOSS BY EVAPORATION AND BY RADIATION AND CONVECTION

auditoriums, also factories, foundries, iron, steel and glass works, mines and other places where workers are subjected to extreme temperature conditions. Maintaining comfortable conditions indoors in summer when the thermometer registers about 95 deg. is a more complicated problem than maintaining the proper condition in winter.

Effective cooling, using cold water or refrigeration, is frequently resorted to in theaters and other public buildings and this practice may be expected to increase.

HOW RELATIVE HUMIDITY AFFECTS HUMAN COMFORT

Relative humidity has a bearing on the well being of man besides having an effect in determining his feeling of warmth. While its effect on health and comfort has never been thoroughly investigated, and while authorities do not agree as to reasons why a high or a low humidity is

harmful, there is general agreement that very high or very low humidities indoors are to be avoided. It is generally accepted that for good ventilation the relative humidity should not be below 30 per cent or above 60 per cent.

Maintaining proper humidity indoors is particularly a problem in cold weather. The reason for this can easily be seen when one considers that most rooms have from 1 to 2 air changes per hour due to infiltration (See Chapter I, p. 48-60 of THE GUIDE) or, that air circulates freely between the outside and inside of most buildings.

TABLE 2. CONDITION OF SENSIBLE PERSPIRATION FOR VARIOUS ATMOSPHERIC CONDITIONS

DEGREE OF PERSPIRATION	EFFECTIVE TEMPERATURES AT	
	95 Per Cent Relative Humidity	20 Per Cent Relative Humidity
Forehead clammy	73	75
Body clammy	73	75
Body damp	80	85
Beads on forehead	85	90
Body wet	85	90
Perspiration on forehead runs and drips	90	95
Perspiration runs down body	90	95

The psychrometric chart, Fig. 1, shows that one pound of dry air at 30 deg. fahr. can have a maximum of only 24 grains of moisture even if the relative humidity is 100 per cent. If this air upon coming indoors is heated to 70 deg. fahr. without addition of moisture the moisture content will still be the same but the relative humidity will fall to 23 per cent. Likewise an outside temperature of zero with 100 per cent relative humidity will give 5.2 per cent relative humidity inside while 20 deg. below zero outside will give 1.7 per cent inside. 70 deg. air with relative humidity of 20 per cent or lower is noticeably dry or has a great affinity for moisture and takes it rapidly from any available source, resulting in raising of dust, damage to glued furniture, and a parched or irritated condition of the mucous membrane of the outer portions of the respiratory tract. Contrary to common belief, however, the total moisture removed from the entire respiratory tract through breathing a given mass of air is practically the same indoors with 70 deg. and 5.2 per cent relative humidity as it is out-of-doors with zero and 100 per cent relative humidity.

There is likewise difference of opinion concerning the relation of high relative humidity to health and comfort. A high humidity indoors is objectionable due to precipitation on windows and other cold surfaces and a general tendency for a damp unsanitary condition to develop.

CHAPTER XXIV

SYSTEMS OF VENTILATION

Methods of Fan Application, Air Supply, Fan Selection, Types of Equipment, Unit Systems.

VENTILATING systems may be classified as follows:

Method of Supply	Method of Exhaust
Window (or other natural means)	Gravity
Gravity	Fan
Fan	Gravity
Fan	Fan (with or without recirculation)

In addition to these, there is also a system employing fan supply without exhaust fans or gravity exhaust duct work, the exhaust depending entirely on natural leakage around doors and windows and through open entrance doors. This system has seen considerable use in connection with theatres and auditoriums where air cooling and refrigeration is employed and where a large percentage of the air is recirculated. A more modern adaptation of this type of system for theatres includes a system of exhaust recirculating ducts extending back to the inlet of the supply apparatus, with an exhaust relief branch duct leading to the outside through which most of the discharged air is forced. The air forced outward by interior excess air pressure is equivalent in volume to the outside air taken in by the supply apparatus.

The movement of air in natural ventilation systems is produced by the difference in density between that of the air in building and that of the outside air, coupled with the action of the outside air movements on ventilators, openings and the building itself. The greater the difference in temperature between the two columns of air, other conditions being equal, the more rapid the air movement.

Outside air movements may either augment or retard the air movements due to temperature difference, depending upon the velocity and direction of the outside currents, the location and character of openings and the character of the building. (See Chapter XXXIII, Natural Ventilation.)

With mechanical systems the circulation of air is maintained positively and uniformly regardless of outside air conditions and when properly designed and operated they will also furnish any desired temperature or humidity under automatic control.

Five methods of fan application in heating and ventilating are common, as follows:

Material for this Chapter originally prepared by E. P. Heckel, Jno. Howatt, Samuel R. Lewis and W. A. Rowe. (Edited for this edition by Perry West.)

1. Fan system for supplying both heating and ventilation.
2. Fan system for supplying air for ventilation, with direct radiation for supplying heat.
3. Fan system for supplying air for ventilation and a portion of the heating, with direct radiation for supplying the remainder of the heating.
4. Fan system for supplying entire heating (no ventilation supplied).
5. Fan system for supplying ventilation only.

Typical installations of the first type of system will be found in churches, theatres, auditoriums and other places of assembly requiring a relatively large amount of ventilation and little heating. The second type of system is usually provided in hotels and office buildings where only certain rooms need ventilation. Experience has shown that the third type is economical for schools, manufacturing plants doing special work, hotels and other places where a properly controlled air volume is essential. The fourth type of system is especially adapted to industrial plants and shops to convey heat to the points desired and to create an effective air motion and uniform temperature with minimum heat loss. Unit heaters are an adaptation of this system. When the fan is required to do both heating and ventilating it is necessary to keep it in operation. Great success has been reported in school work with systems of this kind, particularly because of flexibility, easy temperature and humidity control, and economy of operation.[1] The fifth type of system is used in connection with the ventilation of kitchens, restaurants, dining rooms, some places of assemblage and in industrial plants where exhaust or fresh air dilution systems are employed for the removal of heat, vitiated air or other objectionable atmospheres.

The Fan System for Heating and Ventilating consists of a combination of a fan operating in conjunction with a blast heater, with or without a system of air distributing ducts. An air washer or humidifier may be added when required without otherwise changing the type of system. When used for ventilating purposes, the fan will be required to supply whatever amount of air is specified to meet the ventilation requirements. The system may be arranged so that the fan will either blow or draw the air through the heaters. Each arrangement possesses its own peculiar advantages, but the selection depends largely upon the individual requirements of the installation.

The draw-through apparatus is usually employed in factory buildings on account of its compactness as well as on account of the advantage gained by connecting directly to the piping system. In this case the temperature of the air delivered will be the same for all parts of the building. The blow-through apparatus is used in public buildings, or wherever different air temperatures and independent air temperature regulation are required for different rooms of the building. The use of a by-pass around the heating coils permits the mixture of hot and cold air in any desired proportions, by the use of a mixing damper at the point where the two ducts, one from the heater, and one from the by-pass, join to form one duct leading to the room. In the case of public buildings, the

[1] AMERICAN SOCIETY HEATING AND VENTILATING ENGINEERS TRANSACTIONS, Vol. 25, 1919. Comparative Study of Natural and Mechanical Ventilation for School Rooms, Legg & Walker; Vol. 28, 1922, Intermediate and Junior High Schools in Detroit, H. W. Anderson; Vol. 29, 1923, Heating and Ventilating Chicago Schools, John Howatt.

fan frequently blows the warm air into a space termed a plenum chamber, from which the air ducts radiate to the various rooms of the building; this arrangement is sometimes called the plenum system of heating and ventilating.

Air supply systems may be distinguished as upward and downward systems; the former being sometimes used in such buildings as theatres and auditoriums where people are associated closely. Air is supplied near the floor and exhausted through grilles in or near the ceiling.

The downward plan is used in schoolrooms, hospitals, and other public buildings, air being introduced about 8 ft. above the floor and drawn out near the floor. This system is frequently used in theatres where the air is introduced downward from the ceiling and removed from under the seats. The selection of either system depends upon conditions confronting the engineer.

The amount of heat to be supplied is governed by the losses from transmission plus those from infiltration, with proper allowances for heat supplied by persons, lights, mechanical apparatus, or processes. Temperatures usually specified for various types of buildings are to be found in Table 1, Chapter I.

The amount of air to be supplied depends largely upon the type of service required, the amount of heat to be supplied or removed, the perfection of ventilation demanded, etc.

The total quantity of air to be circulated in an indirect heating system, either mechanical or gravity type, is demonstrated in the seven cases set forth in the Fig. 1, Cases 1 to 6, page 383 as follows:

H = heat loss of room or building as determined by formulae and data given under Chapter I (B.t.u. per hour).
M = weight of air passing into room per hour in pounds from the heating system.
M_r = weight of air recirculated per hour, pounds.
M_o = weight of air drawn into the system from the outside for the ventilation requirements per hour lb. and passed through the indirect radiation system.
M_b = weight of tempered air by-passed around the reheater per hour, pounds.
M_h = weight of air passed through heater or reheater per hour, pounds.
t = mean air temperature of the room of building.
t_o = mean outside air temperature.
t_1 = mean temperature of the air entering the heater.
t_2 = mean temperature of the air leaving the indirect radiator.
t_x = temperature loss assumed in the air duct system.
t_y = temperature of the air entering the room or building.
0.24 = specific heat air of constant pressure. (B.t.u. required to raise 1 lb. of air 1 deg. fahr.)

Note 1.—The mean temperature (t_2) if the air leaving gravity indirect pin type cast-iron heaters may be taken from the data in Chapter II.

Note 2.—The mean temperature (t_2) of the air leaving all other types of indirect heaters including blast heaters, reheaters, tempering heaters and unit heaters should be taken from reliable published data of the manufacturer of the particular type of heater to be used.

Note 3.—The calculated amount of heat (H) in B.t.u. per hour to be supplied any type of indirect radiation by the boiler equipment may be ascertained by the following formula:

$$H = 0.24\ M_h\ (t_2 - t_1)$$

Note 4.—The amount of steam condensed per hour, per square foot, or per lineal foot of surface in a heater unit or battery, may be taken from manufacturers' tables for the

type of heater specified for any condition of steam pressure, air velocity through heater, entering air temperature and final air temperature desired. The amount of heating surface shall then be multiplied by the condensation per square foot to obtain the total condensation in pounds of steam per hour. This same amount of condensation may be checked from the air quantity specified, by the following formula:

$$\text{Cond. pounds per hour} = \frac{\text{cu. ft. of air per min.} \times 60 \times \text{temp. rise deg. fahr.}}{55.6 \times \text{latent heat of steam}}$$

Case 1—When all of the air passing through indirect heater is recirculated air:

$M_o = 0$; $M_h = M_r = M$; Temperature of air entering heater, $t_1 = t$; $M = \frac{H}{0.24\,(t_y - t)}$ ....(1)

Case 2—When all of the air passing through the indirect heater is drawn from the outside:

$M_r = 0$; $M_h = M = M_o$ Temperature of air entering heater, $t_1 = t_o$ $M = \frac{H}{0.24\,(t_y - t)}$ ....(2)

Case 3—When a portion of the air passing through the indirect heater is outside air and the remainder recirculated air:

$$M_h = M = M_r + M_o = \frac{H}{0.24\,(t_y - t)} \quad \text{.....(3)}$$

In this case M_o is known from the ventilating requirements and the amount of air to be recirculated is ascertained by the following formula: $M_r = M - M_o$ or $M_r = \frac{H}{0.24\,(t_y - t)} - M_o$ .....(4)

The mean temperature of the air entering the indirect heater is ascertained by the following formula:

$$t_1 = \frac{M_o\,(t_o + 460) + M_r\,(t + 460)}{M_o + M_r} - 460 \quad \text{.....(5)}$$

Case 4—When all of the air circulated is drawn from the outside and passed through a tempering coil, air washer or humidifier and reheater.

The temperature of the air t_1 entering the reheater will have the same dew-point temperature as the air in the room or building to which the air is delivered, having temperature t and relative humidity as specified. If the relative humidity is not specified it shall be assumed as 35 per cent. If the room temperature is not specified it shall be assumed as 70 deg. fahr.

A relative humidity of 35 per cent for a room temperature of 70 deg. has been selected because this is the highest percentage of moisture which the air can hold without producing dripping on single-thickness windows in cold weather.

In this case: $M = M_o = M_h = \frac{H}{0.24\,(t_y - t)}$ .....(6)

If it is desired to maintain a room temperature of 70 deg. with 35 per cent relative humidity from an outside temperature of zero and with simply an air washer without any water heater in connection, the tempering coil must be of sufficient capacity to heat the entering air from the outside temperature to 88 deg. dry bulb temperature and 52 deg. wet bulb temperature, and this will be represented by t_a in the diagram. In this case the difference is 36 deg. between the wet bulb temperature and the dry bulb temperature and assuming the washer to be 67 per cent efficient, moisture will be evaporated into the air in sufficient quantity to bring the temperature down to 24 deg. which is 67 per cent of 36 deg. Subtracting 24 deg. drop in temperature through the air washer from 88 deg. dry bulb temperature of the air entering the air washer, gives 64 deg. as the final temperature of the air leaving the air washer, the wet bulb temperature remaining at 52 deg. The reheater will heat the air to any temperature necessary to take care of the heat losses since room heating is desired.

The dew-point temperature of the air leaving the air washer and in the room itself will be 41 deg.

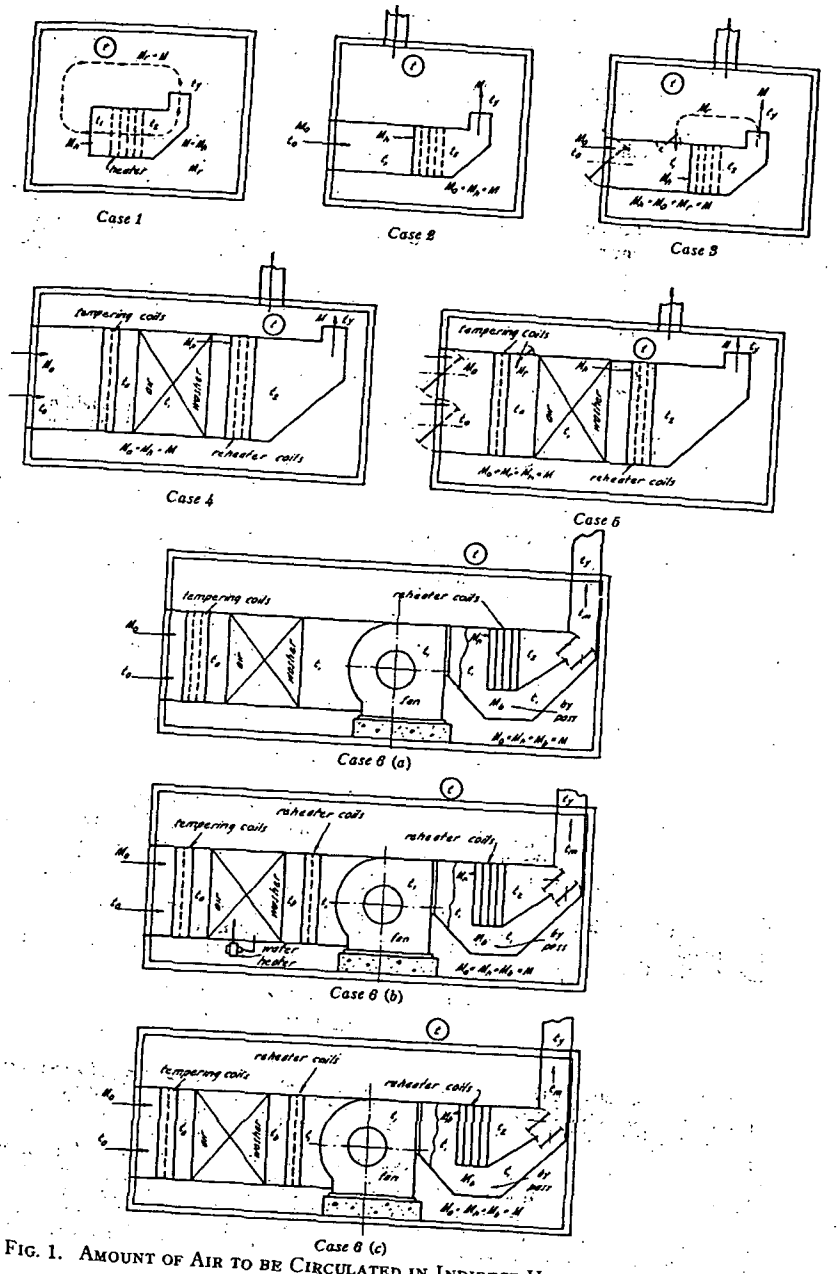


FIG. 1. AMOUNT OF AIR TO BE CIRCULATED IN INDIRECT HEATING SYSTEMS

Using the same illustration and assuming that a humidifying air washer is used with a water heater, the tempering coil will simply have one stack, section or tube row deep to raise the air temperature to about 35 deg. from zero outside temperature. The hot water sprays in the air washer will saturate this air at a temperature of 41 deg. and the reheater will simply raise this temperature to any point required to maintain a room temperature of 70 deg. and a relative humidity of 35 per cent.

The amount of heat to be furnished by the water heater in connection with the humidifying air washer is made up of the sum of two factors—*First:* to heat the specified air volume from the temperature leaving the tempering coil to the saturated air temperature leaving the washer, and *Second:* to evaporate sufficient moisture into this air to saturate it at the temperature required.

If only 23 per cent relative humidity is desired in the room in connection with 70 deg. dry bulb temperature, the temperature entering the air washer, without water heater will be 64 deg. dry bulb, and the temperature leaving the air washer will be 48 deg. dry bulb, which is a drop of 16 deg. through the washer or 67 per cent of 23½ deg. difference between 64 deg. dry bulb and the corresponding 40½ deg. wet bulb temperature.

The illustration in connection with Case 4 indicates that this arrangement is used entirely for heating the room by the fan system. In many cases the heat losses in a room or building are taken care of entirely by direct radiation, and in such cases the final temperature of the air leaving the heater will probably be in the neighborhood of 80 deg. In such a case the same arrangements of tempering coils and reheaters will be used. The arrangement shown in the diagram contemplates the same air temperature being delivered to all rooms on this system, and will not be applicable to the heating of several rooms where individual control of each room is desired.

Case 5—When a portion (M_o) of the air circulated is drawn from the outside and the remaining M_r recirculated air, the air drawn from the outside is passed through a tempering coil and the mixture of air, from the outside and recirculated air, being passed through an air washer or humidifier and a reheater.

Similar conditions will apply to Case 5 as have been outlined for Case 4 except that a percentage of recirculated air at a different dry and wet bulb temperature and a different percentage of relative humidity will be mixed with the fresh air after it has been warmed by the tempering coil.

In Case 5, (M_o) is known from the ventilation requirements as specified, and the amount of air permitted to be recirculated is, therefore:

$$M_r = \frac{H}{0.24\ (t_y - t)} - M_o \qquad (7)$$

Case 6 (*a*, *b*, *c*)—When all of the air circulated is drawn from the outside, passed through a tempering coil and air washer or humidifier, a portion of the tempered and conditioned air passed through an indirect heater or reheater and a portion of the tempered and conditioned air by-passed around the reheater and the mixture passed into the room or building for heating and ventilating.

The weight of air to be circulated per hour equals (M_o) as determined by the ventilation requirements. The dry bulb temperature of the mixture of tempered and reheated air entering the room or building is to be ascertained by the following formulae:

$$M_o \times 0.24\ (t_y - t) = H \qquad (8)$$

$$t_y = \frac{H + 0.24\ M_o t}{0.24\ M_o} \qquad (9)$$

This case illustrates the arrangement of apparatus when the heating of several rooms is required with individual control of temperature for each room. The arrangement of apparatus, including tempering coil, air washer or humidifier, retempering coil and reheater coil, will be the same as has been outlined in Case 4.

The air leaving the reheater and the air by-passed around the reheater, although having different dry bulb temperatures, will have the same dew-point temperature as the air (t) in the room or building to which the air is delivered and with relative humidity as specified; if no relative humidity is specified it can be assumed as 35 per cent. If no room temperature is specified it should be assumed as 70 deg. The relative weights

of air passed through the reheater and by-passed around the reheater shall be ascertained by the following method:

X = parts of reheated air in mixture.
$(1 - X)$ = parts of tempered air in mixture.
t_y = mean dry bulb temperature of the mixture entering room or building.
t_x = loss of temperature in the duct system.
t_1 = mean dry bulb temperature of the air entering reheater and by-pass.
t_2 = mean temperature of the air leaving the reheater.

$$(X)\ (t_2 + 460) + (1 - X)\ (t_1 + 460) = (t_m + 460) \qquad (10)$$

t_m = mean temperature of air entering the duct system = $(t_y + t_x)$.
SOLVE: for X. Then $M_h = X$

M_h is the weight of air in pounds per hour to be passed through the reheater. The temperature (t_y) will ordinarily be different for each room of the building. The *total weight* of air passed through the reheater will be the sum of the requirements for all the rooms.

Case 7—Indirect system for warming the air drawn in from the outside for ventilating purposes only. (When an indirect system is employed to warm the air drawn into the system from the outside for ventilating purposes only, the heat loss is provided for by direct radiation or by some other means).

The weight of air to be circulated per hour is (M_o) as may be determined from the specified ventilation requirement $M_h = M = M_o$. The temperature of the air delivered to the room (t_y) shall be assumed 5 deg. higher than room temperature (t) specified.

a. If no air-conditioning apparatus is to be employed the arrangement is similar to *Case 2* where $t_1 = t_o$ and $t_y = t + 5$.

b. If air-conditioning apparatus is to be employed the arrangement is similar to *Case 4*; $M_h = M = M_o$.

Loss of Temperature in Duct Systems (t_x):

a. When the indirect heater and duct system, are located in the enclosure to which the air is to be delivered, it may be assumed that there is no loss of temperature between the indirect heater and the point or points of discharge into the enclosure. $t_x = 0$.

b. For gravity indirect heating, a loss in air temperature of 5 deg. for the first floor, 8 deg. for the second floor, and 10 deg. for the third floor between the indirect radiator and room register can be assumed.

c. For ducts run underground an allowance must be made based on the estimated heat loss of the duct, assuming an average temperature of the ground of 55 deg. fahr.

d. For ducts run in outside walls to the second floor and above, a loss of not less than 10 deg. shall be used in the calculations.

When the heating and ventilation requirements have been found the size of the heater and fan are calculated for a given friction, temperature range, pressure loss in ducts, etc. Pressure losses build up rapidly as velocities are increased and generally vary approximately as the square of the velocity. The allowable pressure loss through the heater should in general not exceed 50 per cent of the total static pressure of the system. In public building practice allowable pressure loss through tempering coils and reheaters should be under ½ in. of water and when an air washer is used the friction through the tempering coil and reheater should not exceed 40 per cent of the total resistance as a rule.

For data on design and construction of ventilating duct systems, see Chapter XXVIII.

Factory work permits greater friction allowance for the heaters where duct runs are comparatively short and the resistance of the heater is a large part of the entire pressure loss in the system.

The fan can be selected when the following facts are known:

1. Quantity of air required in cubic feet per minute.
2. Static pressure of system (ducts, heaters, air washers, filters, entrance connections, etc.). For data on selection of fans, see Chapter XXVI.

The quantity, velocity and pressure of air delivered by the fan should be determined by the A. S. H. & V. E. Standard Code for Testing Centrifugal and Disc Fans (See TRANSACTIONS, 1923, Vol. 29, p. 407).

A fan installation rightly designed and operated will be quiet and efficient, but every precaution should be taken to prevent vibration or sound transmission to the rooms.

It is usually more effective to float the entire mechanical apparatus on cork, including its foundations, than to attempt to isolate each separate apparatus. There are several systems for the sound-proofing of machinery available, and contracts may be made covering guaranteed and assured results.

For data on ventilation requirements for different kinds of buildings and for the effects of ventilation see Chapter XXIII, Modern Standards of Ventilation and Measurement of Air Quality and Quantity.

For data on Air Conditioning and Cooling, see Chapter XXV.

For data on the Use of Ozone in Ventilation, see Chapter XXX.

For further guidance in determining the quality of ventilation usually desirable for different kinds of buildings and in the selection of the class of ventilating apparatus which may be used for meeting these respective requirements the following data is given.

TYPES OF EQUIPMENT SUGGESTED FOR ATTAINING SPECIFIED SYNTHETIC AIR CHART PERCENTAGES

The following classification is given to assist in selecting the type of equipment necessary to attain certain percentages on the Synthetic Air Chart. It will be understood that considerable variation may be found in certain classes of equipment due to the individual ideas on the part of the designer, the character of the installation work, the location of the building in which the equipment is installed, etc.; nevertheless, if the equipment is properly designed, installed and operated, it will give at least the percentage listed under any particular classification. To design an installation approaching 100 per cent, it is necessary to provide apparatus for heating and humidifying the air, for thoroughly cleaning it and properly distributing it with controlling devices that will maintain the temperature and humidity in conformity with the comfort lines as given by the Research Laboratory of the AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS. Any equipment omitted or any part that is ineffective will reduce the final percentage attained.

Class "A" equipment capable of attaining over 95 per cent on the

Synthetic Air Chart, consisting of a mechanical system including the following apparatus:

1. Mechanical air supply having a maximum capacity of 30 cu. ft. per minute per occupant.
2. Mechanical exhaust equipment.
3. Excellent air distribution.
4. Accurate automatic temperature control.
5. Efficient humidifying apparatus.
6. Accurate automatic humidity control devices.
7. Efficient air cleaning apparatus.

Note.—It is understood that 100 per cent efficiency is a physical impossibility since this would mean 100 per cent efficiency in the air cleaning device, in air distribution, in temperature control, etc. Perfect results of this kind have not yet been obtained in practice, although it is possible to obtain approximately 99 per cent of the Synthetic Air Chart with an apparatus of this kind carefully designed and installed and skillfully operated.

Class "B" equipment capable of attaining from 90 to 95 per cent on the Synthetic Air Chart, consisting of a mechanical system including the following apparatus:

1. Mechanical air supply having a maximum capacity of 30 cu. ft. per minute per occupant.
2. A well designed gravity exhaust system.
3. Efficient air distribution by properly located supply and exhaust registers.
4. Automatic temperature control.
5. Adequate humidifying apparatus.
6. Automatic humidity control.

Note.—All cleaning devices have been omitted from Class "B" as 95 per cent can be obtained under ordinary conditions without air cleaning. In exceptionally clean localities higher percentages will result. Where the air contains considerably more than the average amount of dust slightly lower percentages may result. Air cleaning apparatus may be substituted in Class "B" for automatic humidity control without materially affecting the final percentage.

Class "C" equipment capable of attaining from 85 to 90 per cent on the Synthetic Air Chart, consisting of a mechanical system including the following apparatus:

1. Mechanical air supply having a maximum capacity of 30 cu. ft. per minute per occupant.
2. Gravity exhaust.
3. Efficient air distribution by properly located supply and exhaust registers.
4. Automatic temperature control.
5. Adequate humidifying apparatus.
6. Humidity control from one or more selected points or manual control.

Class "D" equipment capable of attaining 80 to 85 per cent on the Synthetic Air Chart, consisting of a mechanical system including the following apparatus:

1. Mechanical supply having a maximum capacity of 30 cu. ft. per minute per occupant.
2. Gravity exhaust.
3. Good air distribution.
4. Automatic temperature control from one or more selected points or manual control.

Class "E" equipment capable of attaining from 75 to 80 per cent on the Synthetic Air Chart.

(*a*) Mechanical air supply with gravity exhaust but without air cleaning device, humidifying apparatus, temperature or *humidity control.*

(*b*) Direct-indirect systems with either mechanical or gravity exhausts.

(*c*) Open window and other so-called natural systems of ventilation.

TABLE 1. RECOMMENDED PERCENTAGES OF VENTILATION PERFECTION BASED ON THE SYNTHETIC AIR CHART*

	Per Cent
Schools:	
Class Rooms	92
Manual Training Rooms	90
Domestic Science Rooms	90
Amphitheatres	90
Corridors	85
Churches	85
Hospitals:	
Wards	90
Operating Rooms	95
Other Rooms	90
Theatres:	
Auditorium	85
Dressing Rooms, etc	85
Dance, Lodge and Assembly Halls	85
Office Buildings:	
Offices in office buildings or other buildings where persons are continuously employed	90
Department Stores	88
Other Stores	88

Factory Buildings:

The percentage desirable for factory buildings will vary over a considerable range, depending upon the character of the work and the processes employed, modified to a considerable degree by the dust content of the air and the possibility of maintaining it free from objectionable dust and fumes. This will require careful study for each installation.

The following Table 2 is offered as a guide for proportioning ventilation on the basis of square feet of floor space and may be used for certain cases where it might be more applicable than the cubic feet per person basis on account of the number of occupants being unknown or subject to possible change, or more applicable than the air change basis where unusual ceiling heights occur.

TABLE 2. AIR REQUIRED FOR VENTILATION BASED ON SQUARE FEET OF FLOOR SPACE

Schools:	
Classrooms	2.0 cu. ft. per minute per square foot of floor area
Assembly rooms	1.5 cu. ft. per minute per square foot of floor area
Gymnasia	1.5 cu. ft. per minute per square foot of floor area

*See Chapter XXXIV for description and data on the use of the Synthetic Air Chart.

Picture Machine Booth	1.5 cu. ft. per minute per square foot of floor area
Dining-rooms	1.5 cu. ft. per minute per square foot of floor area
Kitchens	2.0 cu. ft. per minute per square foot of floor area
Corridors	0.5 cu. ft. per minute per square foot of floor area
Wardrobes and lockers	2.0 cu. ft. per minute per square foot of floor area
Toilet, Bath, Etc.	2.0 cu. ft. per minute per square foot of floor area
Theatres:	
Seating spaces	2.0 cu. ft. per minute per square foot of floor area
Toilets, etc.	2.0 cu. ft. per minute per square foot of floor area
Hotels:	
Assembly rooms	2.0 cu. ft. per minute per square foot of floor area
Dining-rooms	1.5 cu. ft. per minute per square foot of floor area
Kitchens	4.0 cu. ft. per minute per square foot of floor area
Hospitals:	
Wards	1.0 cu. ft. per minute per square foot of floor area
Dining-rooms	1.5 cu. ft. per minute per square foot of floor area
Toilets	2.0 cu. ft. per minute per square foot of floor area
Kitchens	4.0 cu. ft. per minute per square foot of floor area

Note.—See Chapter XXIII (Modern Standard of Ventilation, Etc.) and Chapter XXV (Air Conditioning and Cooling) for further data on the quantities of Air required for Ventilation.

UNIT SYSTEMS[2]

Unit systems consist of an individual unit incorporating all the apparatus necessary for providing, directing and controlling the necessary volume of air heated to the proper temperature for the purpose. Two types are in common use, one for public building work and the other for factory and industrial installations.

All unit heating and ventilating devices consist essentially of small fans connected closely with heat radiating surfaces. Steam or hot water usually is used for heating, and electric motors usually are used for power.

Public Building Work

A unit heating and ventilating machine intended for public building work consists usually of a small rectangular steel cabinet, enclosing the following essential parts:—

1. A fresh air inlet.
2. An air filter.
3. A motor and fan assembly.
4. A radiator or heating element.
5. A cold air or by-pass chamber.
6. Mixing chamber.
7. Air discharge outlet.
8. Fresh air and recirculating control damper.
9. A by-pass or temperature control damper.

Note.—Both the recirculating control damper and the by-pass damper can be manually operated, or the recirculating control damper may be pneumatically controlled from some remote point. The by-pass or temperature control damper can be automatically operated on room temperature by means of thermostatic motor in connection with the use of any pneumatic automatic temperature control system. (See also Chapter XVI.)

When the fresh air inlet damper is open the fresh air is drawn immediately from out of doors, having the dust and dirt removed by means of the air filters. From this point the air is driven by means of the motor

[2]Data on Unit Systems contributed by H. B. Hedges, New York, N. Y.; G. E. Otis, Moline, Ill., and A. J. Nesbitt, Philadelphia, Pa.

and fan assembly and forced up through the machine, using either polyphase, alternating current or direct current motor.

All of the air may be driven through the radiator to be heated and thence to the room, or all of the air may be driven through the cold air or by-pass chamber and thence to the room, or part of the air may be driven through the radiator and part through the cold air chamber in any desired proportion, depending upon the position of the by-pass damper.

The closing of the fresh air damper simultaneously opens the recirculating grille at the floor line, so that there is a free path for the air to circulate by gravity through the radiator. Thus, when the motor is not operating and the fresh air damper is closed, the radiator of the unit becomes an enclosed direct radiator, functioning in the same manner, as any other enclosed direct radiator. By starting the motor during heating-up period in the morning, the air may be drawn from the room at the floor line, heated, discharged, recirculated, reheated and redischarged, this process continuing until the room has reached the desired temperature, thus effecting a tremendous saving in time and fuel in preparation of the room for occupancy.

With this system of ventilation, the air outlets for the room serve strictly in the capacity of vents to permit of displacement and they should be small, with as little exhausting effect as possible. Under such conditions their location is unimportant further than that they be placed at or very near the floor. In the typical layout they are usually placed in the wall opposite the fan unit.

In school work where it is desired to circulate air through adjoining wardrobes, room outlets should be in low panels of doors or near floor in partitions. Wardrobe outlets may be either at floor or ceiling. The latter arrangement is usually preferable from a purely ventilation standpoint but the former provides a better heating effect. By such a plan direct radiation may usually be omitted from such rooms. When half doors or no doors are used between classrooms and wardrobes, outlets from the latter must be at the floor.

With the mechanical unit ventilation system exhaust fans or aspirating coils in vent flues are neither necessary nor desirable, it being the idea to force the air out of the rooms under back pressure. Where the outlets are properly proportioned this has an inflation effect that retards infiltration and assists in diffusion. One vent for each machine is sufficient and both the grille and flue should have a net free area of about 18 sq. in. for each 100 cu. ft. of air delivered per minute by the ventilator.

In order to carry out the principle of diffusion and get proper results from the unit system of ventilation, consideration must be given to the number, size, location and general application of the mechanical ventilators. With a correctly designed system and proper equipment, good diffusion will be effected if the frequency of air change in the room ventilated is equivalent to five or more volumes per hour but the extent to which the desirable effect of air motion is present will be governed both by the frequency of air change and the ceiling height.

On the same principle that underlies the necessary distribution of direct radiation there is a limit to the amount of air which can be distributed from a single point in ventilation work if good results are to be

expected. Practical experiments seem to indicate that this limit is about 1500 cu. ft. per minute with this type of apparatus. In a practical way this determines the number of unit machines to be used in a given case. Where the very best results are desired it is recommended that the capacity of any single machine be limited to 100 cu. ft. per minute per foot of ceiling height.

Mechanical unit ventilators should be located centrally on the outside wall of the room which they serve. Corner locations are liable to result in inefficient and unbalanced distribution. In fact, under adverse conditions, drafts may result from such a location.

Unit ventilators may be recessed but they should never be enclosed or concealed. Not only are enclosures liable to affect the perfection of diffusion, but from a practical standpoint they interfere with proper care and attention by rendering the machine inaccessible. Moreover, there is a certain psychological value to an exposed machine. The occupants quickly learn its purpose and operation with the result that they appreciate its value and see that it is operated and properly cared for.

No single mechanical unit ventilator should be made to serve more than one room by the extension of ducts from the outlet, since this is contrary to all the basic principles of the system. Adjacent rooms, if not sufficient in size and importance to be equipped with individual ventilating systems probably do not require any ventilation.

Where the total heat required is in excess of the rated capacity of the unit, the unit must be supplemented by direct radiation. Otherwise, the unit can be used for both heating and ventilating without direct radiation.

No special treatment of vent flues is required by this system, the vitiated air being discharged from the building in the same manner, as all other mechanical systems. It has been found that the best results have been obtained where the cross sectional area of the vent flue does not exceed 20 sq. in. per 100 cu. ft. of air per minute.

Industrial Service

Unit heaters for industrial work consist of a heating element over which air is forced or drawn by means of a power driven fan which also distributes this heated air to the space to be heated. The area that can be served by one unit varies according to the type of unit and the location of the unit within the building.

Industrial units are available in capacities from that of the smallest disc or propeller type fan up to that of gangs of centrifugal fans, and in ranges, expressed in heating output, from perhaps one hundred square feet of radiation up to several thousand square feet of radiation.

They may be placed on the floor, or may be suspended from overhead construction, and may be heated by steam or water or other fluid, or may be direct fired, with coal, oil or gas.

There has been a remarkable recent expansion in the demand and in the production of all sorts of industrial heaters, and their use no longer is confined, by any means, to industrial buildings alone.

The tendency is apparent to return after some digression, toward a location for the units as near the floor as is practicable, especially with

suction ducts or high velocity outlets arranged to move the cold heavy stratum of air which is likely otherwise to lie close to floors.

The service of industrial unit heaters is essentially that of heating, and recirculation is usual, with dependence on windows and doors for ventilation. Since the fans can be operated without heating the radiators there is some advantage from them in warm weather.

Due to the very high heat transmission rates from radiators over which air is driven at high speed by fans, industrial unit heaters usually effect material space economies.

Industrial units are now being employed for washing, humidifying, dehumidifying and otherwise conditioning air for manufacturing processes.

See Chapter X for further data on Unit Systems for Heating and Air Conditioning.

CHAPTER XXV

AIR CONDITIONING AND COOLING

Air Supply, Relative Humidity, Air Cooling, Refrigeration, Humidifying, Dehumidifying, Automatic Controlling Devices, Cleaning Units.

TEMPERATURE and humidity of surrounding air is an important factor influencing comfort and efficiency. While temperature and humidity affects human comfort, it also has an important bearing in the industrial fields where hundreds of manufacturing processes are dependent for their success upon some definite atmospheric conditions to be maintained.

Climatic conditions, of course, vary with geographical locations. A study of temperature and humidity variations in different localities tends to show that such places having an average wet bulb temperature in the neighborhood of 56 deg. fahr. with corresponding dry bulb temperatures to give an effective comfort temperature of from 62 to 69 deg. are favored with best health conditions. (See Chapter XXIII, page 366).

This chart indicates that maximum comfort is produced when temperature and humidity conditions are approximately such as to give a 64 deg. effective temperature. One condition in combination is 70 deg. dry bulb, 57 deg. wet bulb and 45 per cent relative humidity, which corresponds to a dew-point of 48 deg. and 3.59 grains of moisture per cu. ft.

See Chapter XXIII Figs. 2, 3, 4 and 5 for definite conclusions regarding the relation between temperature, humidity and air motion to produce physical comfort.

Air conditioning is the science of mechanically controlling: (1) temperature, (2) humidity, (3) purity and (4) the movement of air within buildings and other enclosures, thereby controlling the effects of such air upon the people and materials exposed to it.

Conditioning for industrial processes has become an exact science with results measurable in dollars and cents, in a more perfect product, in increased production, in elimination of waste or in some equally important factor. Varying degrees of moisture are required in manufacturing processes and the nature of the product will indicate whether a high or low relative humidity is to be maintained. Heating as well as cooling must be considered in air conditioning work such as that of textile mills, printing plants, bakeries, candy kitchens, laundries, etc., all presenting definite problems. For example, in spinning rooms 75 deg. fahr. and 65 per cent humidity have been found best for the operations; in match factories 68 deg. dry bulb and 55 deg. wet bulb permit continuous operation and reduce fire hazards; in candy dipping rooms 66 deg. dry bulb

---

Material for this Chapter was prepared especially for THE GUIDE by the following committee: E. P. Heckel, *chairman;* W. L. Fleisher, E. S. Hallett and Ernest Szekely.

TABLE 1. AMOUNT OF NEW AIR TO BE SUPPLIED PER PERSON WITH AND WITHOUT AIR CONDITIONING

	Cubic Feet per Minute			Number of Air Changes per Hour
	Without Humidification or Recirculation	With Humidification and Dehumidification but Without Recirculation	With Humidification, Dehumidification and Recirculation	
SCHOOLS—				
Class Rooms	30	20	5 to 10	.....
Assembly Rooms	15 to 25	10 to 15	5 to 10	.....
Gymnasiums	30	25	15 to 20	.....
Toilets	.....	.....	.....	10 to 20
Locker Rooms	.....	.....	.....	5 to 10
Kitchens	.....	.....	.....	20 to 60
Lunch Rooms	.....	.....	.....	10 to 20
THEATRES—				
Seating Space	30 to 50	20 to 30	10 to 15	.....
HOSPITALS—				
Wards	40 to 60	30 to 40	.....	.....
Kitchens	.....	.....	.....	20 to 60
Dining Rooms	.....	.....	.....	10 to 20
Toilets	.....	.....	.....	10 to 20
HOTELS—				
Dining Rooms	.....	.....	.....	10 to 20
Kitchens	.....	.....	.....	20 to 60
Ball Rooms	20 to 30	15 to 20	10 to 15	5 to 10
Work Space	.....	.....	.....	5 to 10
Assembly Rooms	20 to 30	15 to 20	10 to 15	.....

and 50 per cent relative humidity give a high quality product. In some cases, humidity must be supplied, in others, dehumidifying is necessary.

In some cases such as with textile manufacture, the condition of relative humidities of the surrounding air must be sufficiently high to provide for moisture absorption by the materials in process. In other cases the materials in process require air conditioning that will be conducive to a reduction in weight of materials by evaporation. For this reason, it is quite impractical here to give the exact temperature and humidity conditions best suited for the infinite numbers of materials or varying processes. The best suited conditions are quite generally known and understood by those who have studied the effects of moisture conditions in relation to any particular process or product.

Air has certain definite properties and obeys certain well known laws. Therefore, to properly handle problems of air conditioning and cooling, the relation between the wet and dry bulb temperatures, relative humidity and the dew-point should be thoroughly understood.

Dew-point is the temperature of the air at which saturation occurs for a given amount of water vapor. With air at the dew-point the wet and dry bulb temperatures are the same. At ordinary temperatures, the absorption of 1 grain of moisture per cu. ft. reduces the dry bulb temperature 8½ deg.

Relative humidity of air is the weight of moisture actually contained

by the air at a given temperature expressed in per cent of the amount of air it would hold if it were saturated at the same temperature.

The maximum moisture which the air can hold at various temperatures is given by the saturation, or 100 per cent relative humidity curve of the psychrometric chart. Relative humidities between 0 and 100 per cent of saturation are shown by a series of oblique curved lines similar to the saturation curve.

The wet bulb temperatures are given by a series of nearly parallel oblique lines and the numerical values of these wet bulb temperatures are given by the dry bulb temperatures at their intersection with the saturation curve.

Example.—If air is at a temperature of 70 deg. and its moisture content is 4 grains per cubic foot the relative humidity is approximately 50 per cent, since 4 grains of moisture per cubic foot is very nearly 50 per cent of 7.98 grains, the maximum moisture carrying capacity of the air at 70 deg.

Therefore, to provide a final room condition of 70 deg. temperature and 50 per cent relative humidity the air should first be saturated at a temperature corresponding to 4 grains of moisture per cubic foot which has already been referred to as a dew-point of 50 deg.

This condition is easily obtained during the heating season, since during this time of the year steam may be used for varying the spray water temperature through which the air being conditioned is passed, and thus the moisture carrying capacity of the air is raised to the desired point. The problem, however, is reversed in summer. Instead of humidifying, or increasing the moisture content of the air, it must be reduced from some higher level down to a 50 deg. dew-point.

Humidifying is the process of adding moisture to air.

Dehumidifying is the process of removing moisture from the air.

It may be necessary for the example cited, to cool below 50 deg. depending upon infiltration, air liquidage, as well as liberation of moisture from material to the air in the room which is desired.

The necessary dew-point correction value to be considered will, of course, vary with building or room construction. It is also dependent upon dry bulb temperature as well as moisture content differences between inside and outside air conditions. Compensation in dew-point temperature correction should also be considered from a standpoint of moisture liberated by occupants of the room as well as moisture given off by material in process of manufacture.

In air conditioning, the amount of air to be handled by the fan equipment is not covered by any air change or cubical content rule; it should be based and is dependent upon a correct heat balance, handling the required amount of air which when absorbing all sources of heat within a room, will not raise above the predetermined temperature desired for the room.

Example, desired—70 deg. temperature and 50 per cent relative humidity. This corresponds to 50 deg. dew-point. The difference between 50 deg. dew-point and 70 deg. final room temperature is 20 deg. Assume the total value in heat units to be absorbed in maintaining 70 deg. as 20,000 B.t.u. then the air capacity of the equipment is

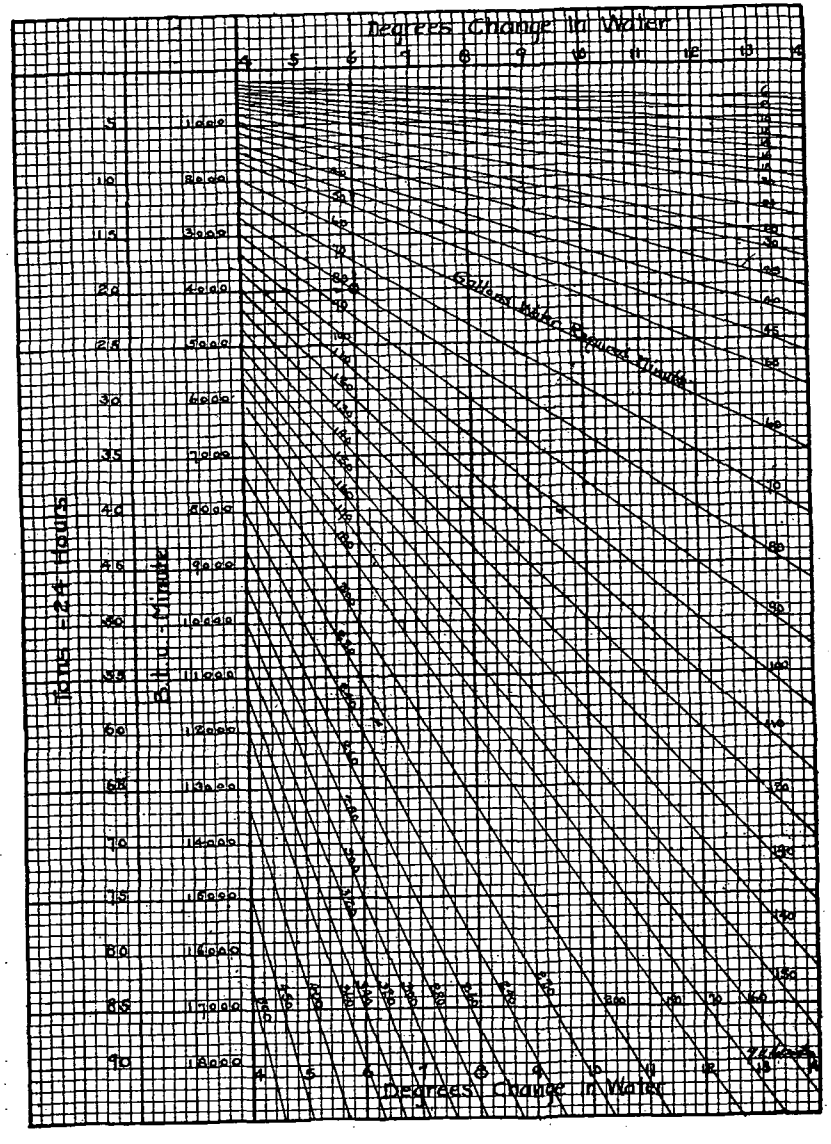


Fig. 1. Gallons Water Required per Minute

$\frac{20{,}000 \times 56}{20}$ = 56,000 cu. ft. per minute. (*Note.* The factor 56 is a convenient factor representing the air volume in cubic feet that will rise 1 deg. in absorbing 1 B.t.u.)

The above briefly expressed shows the method of determining air capacity required for the problem considered.

Dehumidification being required to first cool the air to 50 deg. during warm months of the year involves the use of mechanical refrigeration. The next step is to determine the refrigeration load and water cooling surface requirements. It must not be presumed that the 20,000 B.t.u. factor used in the above example to determine air capacity also represents the refrigeration load.

The refrigeration load should be based upon the cooling of 56,000 cu. ft. of air to at least 50 deg. The total heat to be removed in cooling air to 50 deg. is dependent upon the difference between the total heat of the air before and after cooling.

The total heat to be removed varies with the proportion of the outside air and return air used, and this in turn is governed by the nature of the particular problem and geographical location. It should be understood that the greater the proportion of outside air used during maximum summer weather the greater will be the refrigeration or cooling load.

The usual way of adding moisture to air in large plants is with the use of an air washer while in homes and offices, water pans in furnaces, or devices used in connection with radiators tend to better prevailing indoor conditions. While with air washers the degree of humidity as well as the temperature can be definitely controlled, little attention is paid to these items in the average dwelling as contrasted with factories, theatres, schools and other large buildings.

USE OF REFRIGERATION IN AIR CONDITIONING

The advantages of one method of cooling air over another and the general factors governing the proportioning and design of air conditioning units are of interest to all whose work may bring them in contact with systems using refrigeration. It is the purpose of this section to give those not familiar with this important branch of air conditioning a better understanding of how refrigeration is applied in this work.

The producing of the refrigeration for an air conditioning installation is a problem for the engineer, and is the same as any other refrigerating problem with a varying load. The method of treatment of the air, and its distribution is a separate study involving the entire subject of air conditioning.

The remaining problems, then, in connection with the use of refrigeration in air conditioning is the actual application of refrigeration in a unit or apparatus for cooling the air.

The transfer of heat in air conditioning apparatus is usually accomplished by one of three methods:

1. Passing air through cold water or cold brine sprays.
2. Passing air directly over cold coils.
3. Combination of the above two methods.

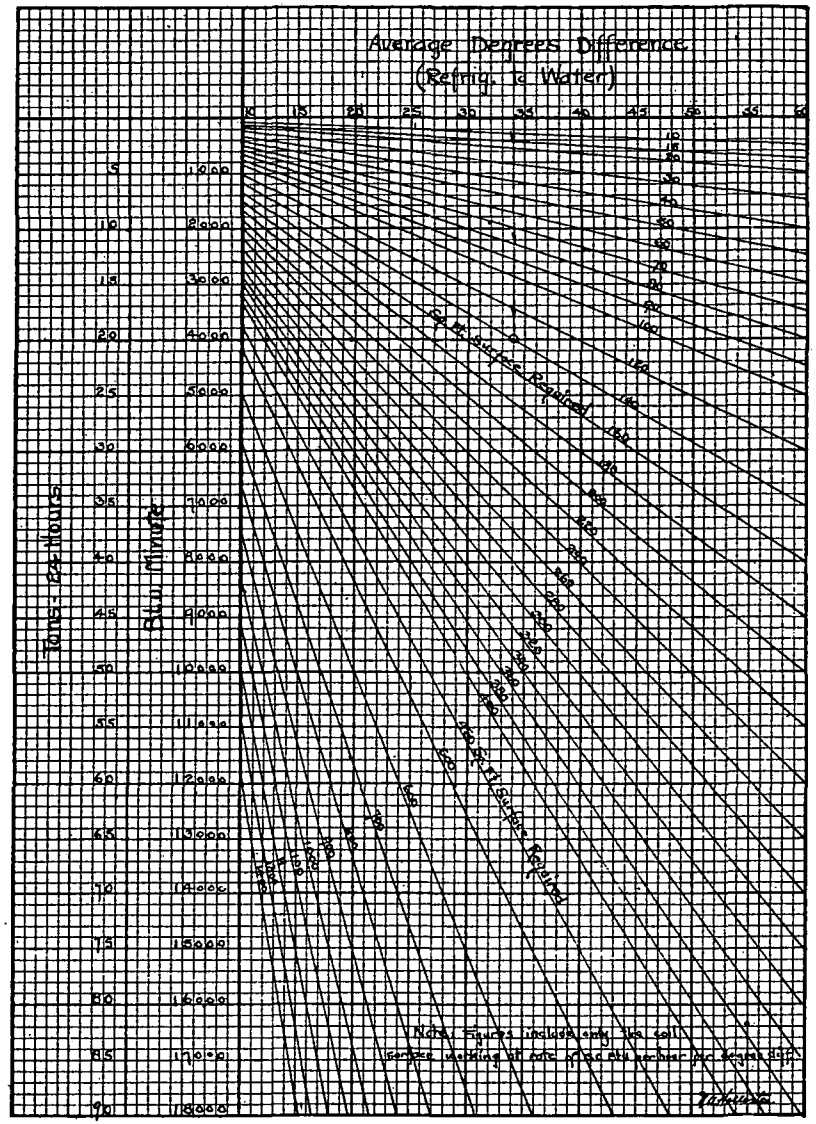


FIG. 2. SQUARE FEET WET COIL SURFACE

COLD SPRAYS VS. COLD COILS

A liquid spray which absorbs the heat from the air and transfers it to cooling coils is more frequently used than cooling coils in direct contact with the air, for the following reasons:

(1) An economic method of securing an enormous radiating surface for heat transfer from the air, (2) relatively small amount of cooling coils surface required, therefore, relatively low first cost, relatively small space and light weight, (3) economy in power for driving compressor, (4) ease of keeping unit clean, (5) ease of controlling effect on air, (6) securing of air cleaning at all times, (7) humidity control during all seasons of the year, (8) continuous cleaning radiating surface, unhampered by any frosting, with accompanied increase of heat transfer, (9) high heat transfer from liquid to air and from liquid to liquid cooling coils.

Water is generally used for spraying when the lowest liquid temperature is not too close to freezing. For lower temperature calcium or brine solutions of varying strengths, according to the requirements, are used.

With the comparatively small temperature differences encountered in such work, as 40 deg. water and 55 deg. air, the need of considerable heat absorbing surface is apparent. When water is sprayed the heat transfer must take place on the surface of the drops and the square feet of surface will depend upon how finely the water is divided. Ten gallons of water sprayed and divided into spheres of 0.25 in. diameter gives about 380 sq. ft. of drop surface. If divided into drops of 0.10 in. diameter spheres, the surface increases to about 1000 sq. ft. The water is divided into almost invisible drops and the square feet of radiating surface secured is correspondingly great.

With water flowing over the cooling coils the rate of heat transfer is many times that secured with air passing over or through the coils even when the coils are dry and not frosted. With the correct design and proportioning 40, 50, or even 60 B.t.u. per hour per sq. ft. per deg. difference may be obtained in practical commercial units as compared to the 2 B.t.u. or 6 B.t.u. from dry coils to air. The high transmission from water to coil, frosting disadvantages and other factors all combine to necessitate much less water-to-coil surface than coil-to-air surface with an accompanying saving of cost, space, and weight.

Many air conditioning installations are operated 24 hrs. per day and on every installation power used for operation is important. It should be understood that with the higher refrigerant temperatures operating at the higher refrigeration plane, the power used by the compressors will be lower per ton of refrigeration effect, than when operated at lower temperatures of refrigerant and at a lower refrigeration plane. This is true regardless of whether ammonia, carbon dioxide, or dielene or any of the other refrigerants are used.

CLEANING UNIT

When using the coil-to-air bunker room designs in order to get contact between the coils and air, the coils must be close together, arranged in some staggered form or with deflectors and baffles. Such arrangements make it almost impossible to allow for proper cleaning.

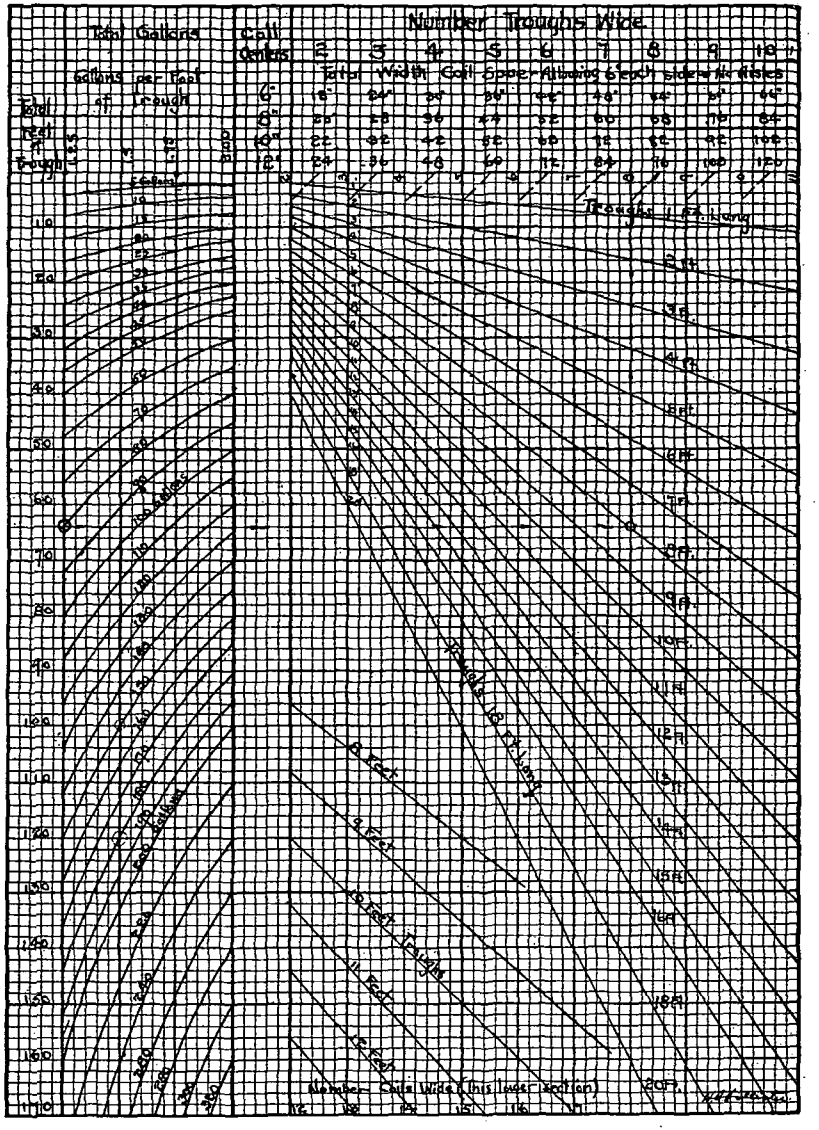


Fig. 3. Troughs

Dirt collects on the wet surfaces as on the wet eliminator or scrubber plate surfaces in the dehumidifying unit but in the bunker room there is no flow of water to clean the surface. Fungus slime frequently collects which, together with rust and dirt and matter carried in by the air, makes frequent cleaning desirable, if not an absolute necessity.

With the spray method the flowing water keeps all surfaces cleaner and the draining of the tanks gives a ready means of carrying away all matter collected.

CONTROLLING EFFECT ON AIR

The control of outgoing air conditions, whether by hand or by automatic devices, is more rapidly changed in the spraying method than in the coil-to-air method. If an operator is cooling the air with coils covered with frost (and they are practically always covered with frost and ice) and he desires to remove the cooling effect he may shut off the refrigerant but the bunker room will continue to treat the air until the frost and ice are melted which may take quite a while. The alternative method of changing the air temperature is to use more space and increase the cost by providing a by-pass duct around the bunker room.

By using a small tank capacity in relation to the volume being pumped it is possible quickly to cool or heat the water and thus have quick effect on the air.

Cleaning of Air

Where dirt or gases carried by the outdoor air which would harm a product or be undesirable for persons, the coil-to-air bunker room does no cleaning and may even add unsatisfactory bacteria due to the unit not being easily kept clean. The spray unit is in itself an efficient air cleaning apparatus.

Humidifying of Air

When refrigeration is used in air conditioning work, whether primarily for lowering the dry bulb or for lowering the humidity, the resulting moisture in the air is seldom as low as in the outdoor air during our many winter months. For many uses too low a humidity is as undesirable as too high a humidity and many times a constant humidity is desired all year to control yearly manufacturing conditions. The coil-to-air method offers no humidifying whatever while the spray type unit changes from a dehumidifier to a humidifier as soon as the water is not cooled. By air recirculation or by heating the water or by both, any desired degree of relative humidity may be produced by the spray type unit and the humidity controlled all year.

Coil and Spray Combined

Without study it might appear that placing the coils in the spray chamber would be the practical solution. It is seldom that this is advisable.

On light duty units, that is, where not much refrigeration is being used in comparison with the air being handled and in some small units, coils may be placed in the spray chamber thus doing away with the lower coil chamber, tank, and troughs, but more coil surface and a large spray chamber must be used.

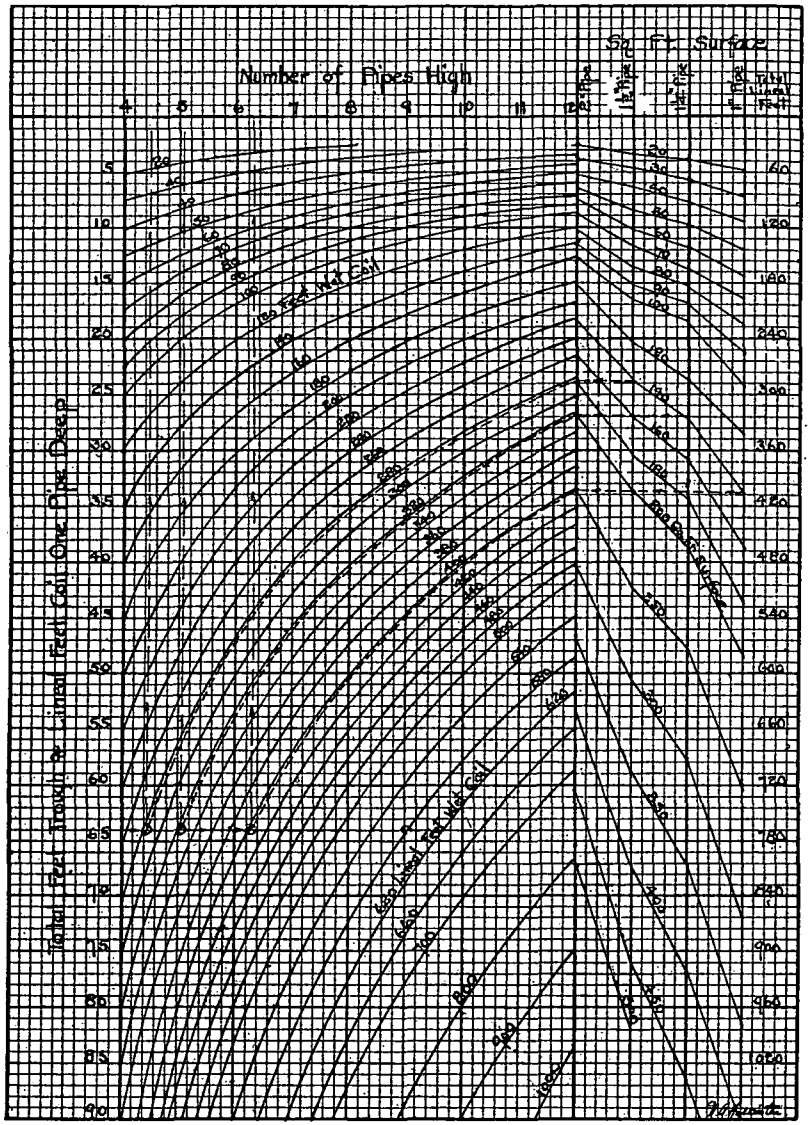


Fig. 4. Size of Pipes and Number of Pipes High

Unless the resistance of the unit is to be increased the spray chamber must be increased to allow for the space occupied by the coil in the air path. If much refrigeration is being used it will be found that the horizontal projected area of the coil is considerable.

Only a small fraction of the water sprayed hits or comes in contact with the coil surface. Some of the water is therefore not cooled during each cycle and to maintain a certain average water temperature some of the water must be cooled considerably lower. As it is not advisable to operate too close to the freezing point, either brine must be sprayed or a low temperature cannot be carried without submerged coil surface as well as extra coils in the spray chamber.

When the sprayed water hits the cooling coil it does not have a tendency to stick to the coil. The result is that a lower total volume of water will be flowing over the total coil surface and less total cooling will be secured per foot of surface used.

If the cost of a larger spray chamber, extra coil surface in the spray chamber, and the submerged coils required and the other factors are favorable, the coils may be used in the upper spray chamber with satisfactory results in some installations.

For some duties a return bend arrangement may be used passing the air through the upper chamber and then down and back through the lower coil chamber. The coils are covered by a film of running water at a lower temperature than the air and as some air will come in contact with the cold water and other cooled surfaces a limited amount of extra cooling may be secured.

There is one important point which is a problem for the refrigerating engineer, but which has sometimes been overlooked. This is the matter of control of the refrigeration. Almost all air conditioning installations, whether with automatic or hand control, give a varying refrigerating load. Systems have been operated using many tons of refrigeration and this load has suddenly been removed owing to changing requirements. Meanwhile the ammonia compressor may be operating, and freezing of the system with accompanying damages results if carried far enough. Ammonia lines in a plant cannot be tapped and valves turned on and off quite as readily as in a steam line. The refrigerating engineer should be fully advised regarding the varying of the air conditioning refrigerating load.

With the accompanying charts no one should have difficulty in checking a layout or making preliminary approximate estimates of the part of an air conditioning unit using ammonia as the refrigerant. It is impossible to give here all the factors governing the use of refrigeration and the allowance to make for different conditions such as coils that are dirty or oily on the inside, coils with poor outside surfaces, the element of time in changing conditions of air treatment, structural considerations, and particularly the action of the water when it is sprayed in the coil chamber in contact with the air. It is not suggested by the author that those unfamiliar with the details of such work use these charts except as a source of general information as to the factors governing the design of such equipment.

Table 2. Cubic Inches of Ammonia Vapor to be Circulated to Produce One Ton of Refrigeration in Twenty-Four Hours

Condenser Pressure		Gage	95	110	125	140	155	170	185	200	215	230	245
		Abs.	109.7	124.7	139.7	154.7	169.7	184.7	199.7	214.7	229.7	244.7	259.7
Temperature of Liquid			61°F.	68°	74.4°	80.3°	85.8°	91°	95.8°	100.3°	104.6°	108.7°	112.6°
Suction Pressure		Temp. of Suction	Ammonia Vapor in Cubic Feet per Minute										
Gage	Abs.												
5"V.	12.2#	−33.6°F	14,880	15,100	15,310	15,525	15,750	15,975	16,175	16,375	16,575	16,775	16,975
4"	12.7	−32.3°	14,320	14,550	14,750	14,950	15,170	15,375	15,560	15,750	15,940	16,120	16,310
3"	13.2	−30.9°	13,820	14,040	14,240	14,440	14,630	14,825	15,010	15,190	15,375	15,560	15,740
2"	13.7	−29.6°	13,340	13,540	13,720	13,920	14,110	14,300	14,480	14,660	14,840	15,010	15,190
1"	14.2	−28.4°	12,885	13,075	13,250	13,445	13,640	13,820	13,990	14,150	14,320	14,490	14,660
0#	14.7	−27.1°	12,460	12,650	12,840	13,020	13,200	13,375	13,540	13,700	13,860	14,025	14,190
1#	15.7	−24.8°	11,700	11,855	12,020	12,210	12,380	12,545	12,720	12,875	13,010	13,150	13,305
2	16.7	−22.6°	11,005	11,160	11,340	11,500	11,660	11,810	11,950	12,100	12,240	12,400	12,540
3	17.7	−20.4°	10,410	10,575	10,710	10,850	11,020	11,175	11,310	11,450	11,590	11,730	11,860
4	18.7	−18.4°	9885	10,020	10,180	10,310	10,450	10,595	10,720	10,850	10,990	11,110	11,225
5	19.7	−16.5°	9400	9540	9690	9820	9960	10,090	10,210	10,340	10,450	10,580	10,700
8	22.7	−11.0°	8200	8310	8425	8550	8675	8790	8895	9000	9100	9200	9305
10	24.7	−7.7°	7550	7670	7770	7880	7990	8090	8190	8290	8390	8480	8580
12	26.7	−4.7°	7010	7110	7210	7320	7420	7520	7610	7700	7795	7880	7980
15	29.7	−0.3°	6320	6420	6510	6610	6695	6790	6860	6940	7025	7110	7190
20	34.7	+6.1°	5445	5530	5605	5690	5750	5825	5905	5990	6040	6110	6190
25	39.7	+11.9°	4780	4850	4910	4990	5050	5110	5190	5240	5300	5380	5420
30	44.7	+17.0°	4250	4310	4380	4440	4500	4560	4620	4680	4725	4790	4840
35	49.7	+21.8°	3850	3910	3970	4020	4070	4120	4170	4220	4270	4320	4370
40	54.7	+26.2°	3510	3560	3610	3655	3705	3760	3810	3855	3905	3940	3980
45	59.7	+30.3°	3220	3280	3320	3360	3410	3450	3500	3540	3590	3630	3680
50	64.7	+34.1°	2980	3020	3070	3110	3150	3190	3225	3275	3310	3350	3390

Estimates as shown by the dotted lines on the charts are made as follows:

1. Total heat load—4,000 B.t.u. per minute
   20 tons refrigeration
2. Design and conditions allow 6 deg. rise in water temperature
3. Average water temperature 44 deg.
4. Average ammonia temperature 10 deg.
5. Difference ammonia and water 34 deg.
6. Gallons handled per ft. of trough 1¼
7. Standard unit available allows 8 ft. long troughs

Fig. 1 shows that 80 gallons water per minute are required.

Fig. 2 shows that 140 sq. ft. of cooling coil surface are required when working at the rate of 50 B.t.u. per hour per square foot per degree difference.

Fig. 3 shows 64 lineal feet trough required.

Also shows 8 troughs and coils wide and space required as follows:

6 in. coil centers require space 54 in. wide
8 in. coil centers require space 68 in. wide
10 in. coil centers require space 82 in. wide
12 in. coil centers require space 96 in. wide

From Figs. 2 and 3 it was found that 140 sq. ft. of surface and 64 lineal feet of troughs were required. Fig. 4 shows the following:

Pipe diameter	1½ in.	1¼ in.	1 in.
Lineal Feet	225	283	404
Pipes High	5	6	7

Pipes High have been increased to eliminate fractions and in designing a unit the lineal feet of coil required would have to be increased in proportion. Allowance must be made for dirty coils, uneven water distribution, quick control of temperatures, and other factors, all of which might double the coil surface shown mathematically by the charts.

The heat-transfer which may be obtained in the upper chamber and the maximum rise in the water temperature, and therefore the use of Fig. 1, will vary with each change in nozzle, pump pressure, time element, pounds of water used per pound of air, water to air temperature differences, and other such factors as might be expected, but once the volume of water and the temperature through which it must be cooled are determined, the design of that part of the apparatus using refrigeration will be a comparatively simple problem to those familiar with such work.

In this work the problems are many and varied, for cooling is used in many industries as well as for the conditioning of air in hotel dining-rooms, theatre auditoriums, and many other rooms where it is desirable to maintain a temperature under that prevailing out of doors.

With modern refrigerating and dehumidifying apparatus properly designed and applied it is possible to obtain most any percentage of ventilation perfection. Unless artificial cooling is resorted to it is hardly

possible to obtain better than 75 per cent perfection in hot sultry summer weather. In hotel, theater, etc., cooling work recirculation will conserve heat in winter and refrigeration in summer.

The development of the science of air conditioning has been rapid and the textile industry has derived great benefit from the adoption of adequate systems. Its applications are wide entering somewhere into every process in making of articles used every day, such as clothing, candy, meat products, and a host of others. Mass production of uniform quality products has been made possible and has placed manufacturing schedules on a year round basis for many industries. It has also improved conditions of comfort and permitted the operation of theaters and other assembly places every day of the year contributing greatly to the health comfort and wealth of the nation.

CHAPTER XXVI

SELECTION OF FANS FOR HEATING, VENTILATION, DRYING AND CONVEYING

Service Requirements, Fan Characteristics, Characteristic Fan Curves, Types of Fans, Selection of Fans, Designation of Fans, Arrangement of Drive.

IN order to properly select fans, it is necessary to know the requirements of the system and the operating characteristics of the various types of fans available. The items of requirements are:

1. Cubic feet of air to be moved per minute.
2. The static resistance of the system.
3. The type of motive power available.
4. The nature of the load such as variable air quantities or pressures.

The items of fan characteristics are:

1. Efficiency.
2. Noise.
3. First cost.
4. Space required.
5. Type of fan best suited to service required.

In order to facilitate the choice of apparatus, fan tables usually show the following factors for each size fan operating against a wide range of static pressures:

1. Volume of air in cubic feet per minute (68 deg. fahr.–50 per cent Relative Humidity —0.07488 lb. per cubic foot).
2. Outlet velocity.
3. Revolutions per minute.
4. Brake horsepower.
5. Tip or peripheral speed.
6. Static pressure.

The most efficient operating point of the fan is usually shown by either bold or italicized figures in the capacity tables.

Fans can be grouped into two general classes:

1. Disc and propeller fans, which produce motion of the air by the thrust effect of inclined blades.
2. Centrifugal fans or blowers, which produce air movement by the centrifugal force generated in a rotating column of air.

The material for this Chapter was prepared especially for THE GUIDE by the following committee: Henry Mathis, *chairman;* W. Gardner, John Howatt and H. F. Maier.

Centrifugal fans or blowers are usually housed, though certain types operate fairly well without housing. These fans or blowers can further be classified according to the type of wheel as follows:

(*a*) Paddle wheel or steel plate type with radial blades.
(*b*) Multiblade with forward curved blades.
(*c*) Multiblade with radial blades.
(*d*) Multiblade with partially backward curved blades.
(*e*) High-speed fans with fully backward curved blades.

CHARACTERISTIC CURVES

Characteristic curves of each type of fan are shown, illustrating the performances of each type. Reference is made to The Standard Test

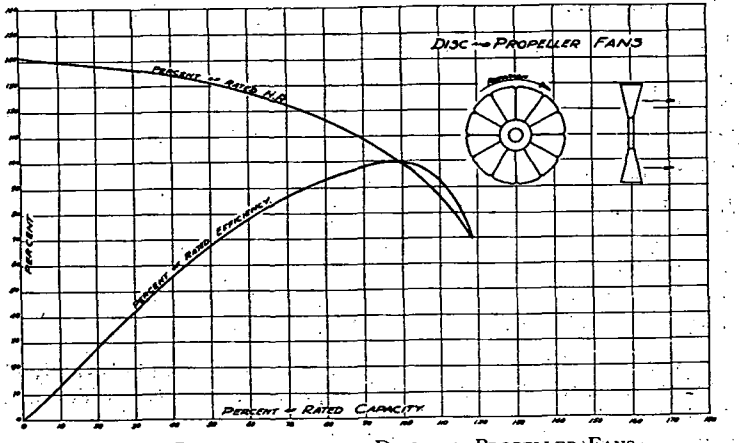


FIG. 1. CHARACTERISTICS OF DISC AND PROPELLER FANS

Code for Disc Fans, Propeller Fans, Centrifugal Fans and Blowers as adopted by the AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS and the *National Association of Fan Manufacturers*. Manufacturers' capacity tables ordinarily list capacities between the dotted vertical range lines. All characteristic curves are for constant speed. The contour of performance curves will vary with different makes and designs, but all fans of a similar type have the same general characteristics.

DISC AND PROPELLER FANS

Disc and propeller fans are best adapted for free air delivery, or operation against slight resistances, as the characteristic curve of these fans shows their rapid reduction in capacity and increase in power as the resistance increases. (See Fig. 1.)

Disc fans properly designed have a satisfactory efficiency at low resistance, being equal in this respect to a good centrifugal fan or blower. Under these conditions, they excel in low first cost and economy of

operation, and are particularly desirable for use in types of unit heaters having low resistance heating elements and in moving large volumes of air with little or no duct work. While this type can operate against considerable resistance, the power increases rapidly and the noise often becomes objectionable, so that they do not always compare favorably with centrifugal fans for such service.

CENTRIFUGAL FANS AND BLOWERS

With centrifugal fans and blowers, when the resistance is increased (at constant speed) the power and capacity decrease. The efficient operating range covers a considerable latitude of capacities and occurs when the static pressures produced are highest, making this type preferred in any system having considerable resistance to overcome.

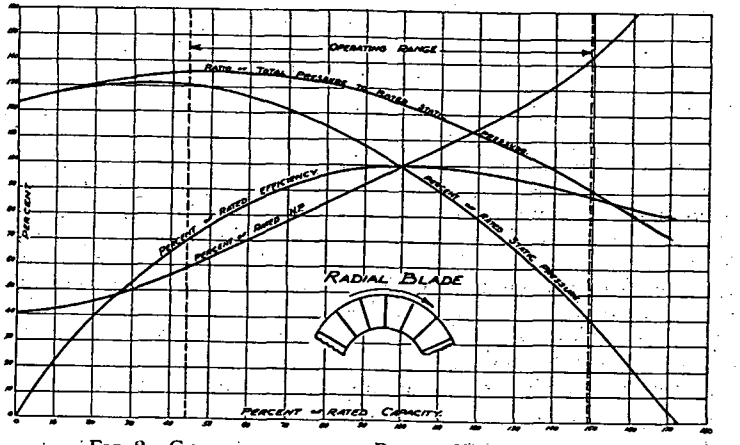


FIG. 2. CHARACTERISTICS OF PADDLE WHEEL FANS

A fan of any type should be chosen at or fairly near the point of maximum efficiency. Selecting a fan beyond this point results in higher capacity, higher outlet velocity, lower efficiency and tendency to create noise.

The paddle wheel type of fan is practically obsolete for ventilation where large volumes of air are to be moved efficiently. Their use is largely confined to such application as conveyors, where quantities of material are to be carried, or to handling air or gases containing foreign materials, as the open construction and flat blades do not allow this material to collect as readily as do other types.

Fig. 2 shows that over the entire useful range the static and total pressure decreases as the capacity increases. The horsepower curve is practically a straight diagonal line increasing from no delivery to full open delivery. A larger size fan is required for a given capacity in comparison with multiblade fans.

The forward curved multiblade fan is the type most commonly used

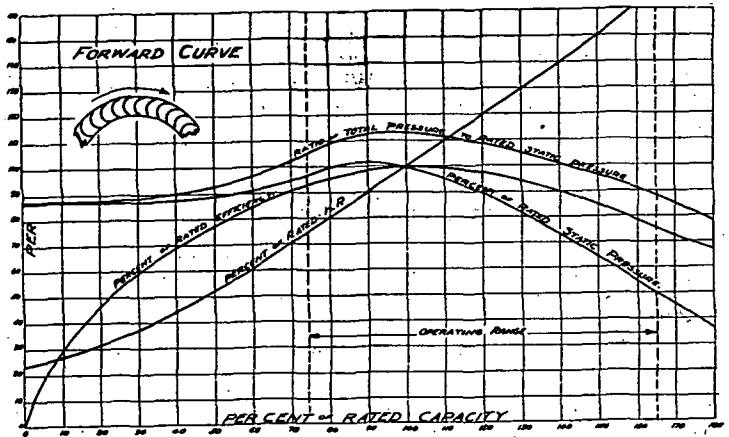


FIG. 3. CHARACTERISTICS OF FORWARD CURVE MULTIBLADE FANS

in heating and ventilating work, as it has a low peripheral speed, a large capacity and is quiet in operation.

The point of maximum efficiency for this fan occurs near the point of maximum static pressure. The static pressure drops consistently from the point of maximum efficiency to full open operation. Fig. 3 shows that this type of fan will have a high and low delivery for a given static pressure at constant speed. Manufacturers' tables ordinarily list only the capacities between the vertical range lines, and selection of fans should be made within this range. The horsepower curve rises continually from low to peak capacity, but if reasonable care be exercised in figuring resistances, there is no danger of overloading the motor.

The multiblade forward curved and partial backward curved fans are good types for general ventilation.

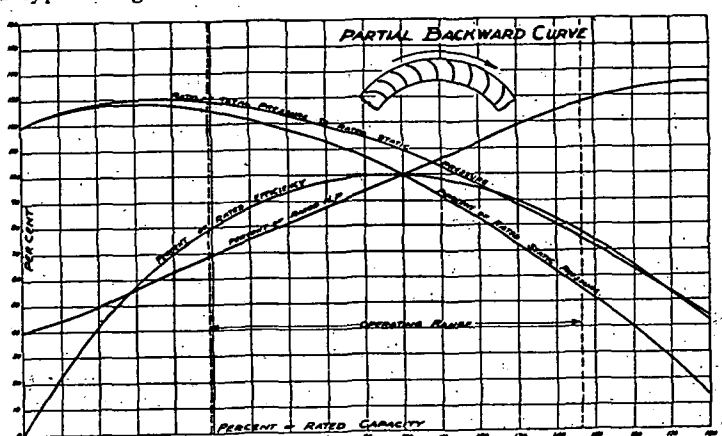


FIG. 4. CHARACTERISTICS OF PARTIAL BACKWARD CURVE MULTIBLADE FANS

The partial backward curved multiblade type of fan lends itself particularly to direct drive through a considerable range of sizes, as this fan must be driven approximately 75 per cent faster than the forward curved multiblade fan for the same results. Fig. 4 shows a continually dropping contour as the quantity of air delivered increases. The horsepower curve gradually increases showing a tendency to flatten at maximum delivery, reducing the probability of motor overloads if the actual resistance is lower than calculated.

As with the paddle wheel fan, the air delivery at a given speed is more constant with varying resistance than is the forward curved multiblade type.

Multiblade fans with radial blades have performance characteristics

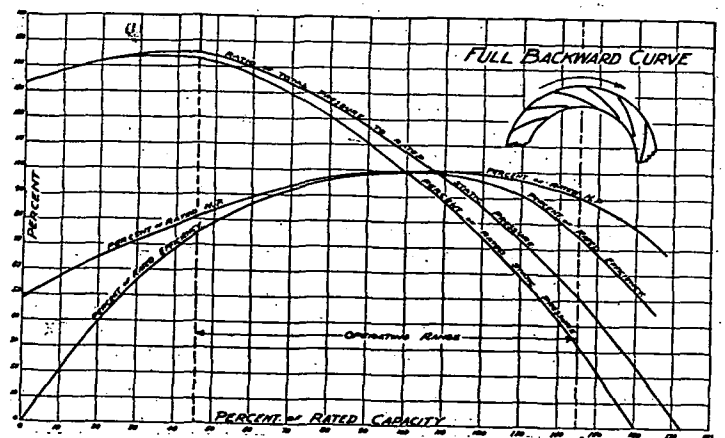


FIG. 5. CHARACTERISTICS OF FULLY BACKWARD CURVED MULTIBLADE FANS

resembling the partially backward curved multiblade fan. The outstanding difference occurs in the revolutions per minute as the radial blade fan must be operated at approximately 80 per cent of the speed of the partial backward curved multiblade fan for like results.

The outstanding characteristics of the fully backward curved multiblade type fan are the steep pressure curves, the non-overloading power curve, and the high revolutions per minute. This fan operates at a peripheral speed of approximately 250 per cent of the forward curved multiblade type for like results. The pressure curves begin to drop at very low capacity and continue to fall rapidly to full opening. This makes it adaptable to parallel operation for such applications as large stoker installations. The steep pressure curves tend to produce constant capacity under changing pressures. Where wide fluctuations in resistance of a system occur, the use of this type of fan is desirable to prevent motor overloading. The maximum horsepower requirements occur at about the maximum efficiency. Consequently, a motor selected to carry the load at this point will be of sufficient capacity to carry the fan over its full range of capacities at a given speed. The speed is high for a given pressure making it adaptable for direct-connected high-speed drives.

The high speed of these fans makes necessary heavier construction, larger shafts and bearings. Consequently, more operating attention and service is required than for the multiblade type. The dimensional bulk for a given duty is one and one-half to two times that of a forward curved multiblade fan.

SELECTION OF FANS FOR VENTILATION

Two important factors in selecting fans for ventilating systems are: Efficiency (which affects the cost of operation) and Noise. First cost and space available are secondary. Proper size fans should be selected to operate at maximum efficiency without noise. Noise in a ventilating system is irritating and cause for complaint; fans must be selected of proper size in order to reduce it to a minimum. Noise may be caused by other factors than the fan; namely, high velocity in the duct work, location of the fan room, construction of floors and walls and improper installation. (See Chapter XXVIII on Air Duct Design and Construction.) Where noise is chargeable directly to the fan, it is either caused by excessive peripheral speeds or the fan is of insufficient size. A fan that is noisy is usually one that is operated at a point considerably beyond maximum efficiency.

For a given static pressure there is a corresponding outlet velocity and peripheral speed wherein maximum efficiency is obtained. If a fan be selected to operate at this point, cost of operation and noise can be held within control.

To aid in selecting fans as near as possible to point of maximum efficiency, there are listed for each static pressure corresponding outlet velocities and tip speeds that will give satisfactory results.

Table 1. Good Operating Velocities and Tip Speeds for Forward Curved Multiblade Ventilating Fans

Static Pressure In Inches of Water	Outlet Velocity Feet per Minute	Tip Speed Feet per Minute
¼	1000–1100	1520–1700
⅜	1000–1100	1760–1900
½	1000–1200	1970–2150
⅝	1100–1300	2225–2450
¾	1200–1400	2480–2700
⅞	1300–1600	2660–2910
1	1500–1800	2820–3120
1¼	1600–1900	3162–3450
1½	1800–2100	3480–3810
1¾	1900–2200	3760–4205
2	2000–2400	4000–4500
2¼	2200–2600	4250–4740
2½	2300–2600	4475–4970
3	2500–2800	4900–5365

Lower outlet velocities than listed above may be used, but care must be exercised to avoid selecting a fan operating below its useful range.

In exhaust ventilating systems where the air column moves toward the fan, noise due to the higher tip speeds and outlet velocities, will not be so readily transmitted back through the air column to the building.

Therefore, higher outlet velocities up to 2000 ft. per minute may be used, but at the expense of increased power. Amply large fans should be used for both exhaust and supply systems, as there may be leakage through joints in the duct work, necessitating the delivery of more air than is exhausted from or supplied through the openings in the various rooms.

Long runs of distributing ducts, heaters, air washers, etc., are usually part of a system where high static pressures are needed; therefore, it is good practice to select fans with the higher outlet velocities and peripheral speeds recommended, as the duct system, itself, will tend to muffle objectionable air sounds. Where the fan is connected with short ducts to register faces, fans with low outlet velocities should be used regardless of the static pressure.

FANS FOR DRYING

Both disc and centrifugal types of fans are used for drying work. The former is well adapted to the removal of moisture-laden air when operating against low resistance and handling air at low temperatures. Motors on these fans are usually of the fully enclosed moisture-proof type so that saturated air or air containing foreign material will not injure the motors.

Unit heaters employing disc or propeller type fans are widely used in the drying field. In drying, disc or propeller fans can be used where duct work is required and air is to be delivered against pressure as the noise developed from the high peripheral speed is not ordinarily objectionable in process work of this nature.

Centrifugal fans or blowers of the multiblade type are generally selected to supply air for drying, as they are capable of delivering large volumes against all pressures with a minimum amount of power.

Belt driven fans are preferred as they make a more flexible and economical unit. Wherever drying is done throughout the year and air requirements change as the drying conditions change, the drying can be speeded up or reduced through control of the fan capacity by either fan speed or volume dampers.

Due to low speeds of forward curved multiblade or paddle wheel type fans, these can be direct connected to reciprocating steam engines and the exhaust steam used in the heating coils. In selecting engine driven fans for drying processes, wherein a large quantity of exhaust steam is used in the heaters, a smaller fan can be used because power economy is not essential.

Where static pressure in a dryer varies and battery operation is required, the full backward curved fan is recommended. This type is well adapted for direct connected motors of the higher speeds.

FANS FOR DUST COLLECTING AND CONVEYING

The application of fans or exhausters for handling refuse, dust, fumes, etc., generated by machine equipment is well covered in Chapter XXXII of The Guide. Information is there given regarding the method for determining the necessary air quantities, velocity required for carrying various materials and method of determining maintained resistance or total static pressure at which the fan is to operate.

The selection of a proper size fan or exhauster is at times governed by the future requirements of the plant. In many instances, additional future capacity is anticipated and should be provided for.

Having determined the necessary volume of air and maintained resistance or static pressure required, the proper size fan is selected from the fan manufacturers' performance chart or capacity table. If the fan is to be pulley driven, its selection is a simple matter. The fan chosen is the size that will provide the required ultimate quantities with the minimum power consumption.

In selecting fans to be direct connected to alternating current constant speed motors, it is necessary to choose one that will operate at a speed

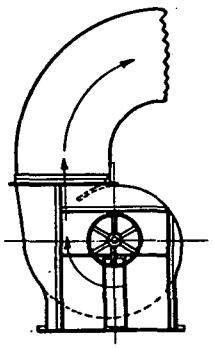


FIG. 6. CORRECT ROTATION

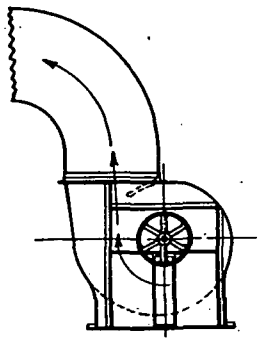


FIG. 7. INCORRECT ROTATION

to accommodate standard motor speeds which on alternate currents are as follows:

60 cycle 425, 490, 570, 680, 860, 1150, 1740 and 3400 r.p.m.
50 cycle 360, 410, 475, 570, 715, 965, 1450 and 2800 r.p.m.
25 cycle 180, 205, 240, 285, 360, 480, 1440 and 1720 r.p.m.

Either belt driven fans or direct connected fans are commonly used. Both types have their advantages and disadvantages. While a fan driven by a belt requires more space, more upkeep and more loss in power due to belt slippage, the belted fan is suitable in a plant where fans are changed from time to time to operate on different systems. It is well known that alternating current motors of higher standard speeds have better efficiencies than the low speed motors. Therefore, the overall efficiency of a belt driven fan and motor will usually exceed that of a fan direct connected to a less efficient motor. Low speeds A. C. motors, although sometimes used, are not to be recommended as they are less efficient and higher in cost than high speed motors. (See Chapter XXVII on Motive Power and Controls for Fans.)

Direct connected units require a minimum of space, no loss in power transmission and less attention. The speed, however, is fixed. Variable speed motors with controllers may be used, but are expensive in first cost and maintenance, and inefficient at the reduced speed.

GENERAL SUGGESTIONS

Single inlet, single width fans should be selected wherever possible. If double width, double inlet fans are selected, care must be taken that both inlets have the same free area. If one inlet is obstructed more than the other, the fan will not operate properly, as one half of the wheel will deliver more air than the other half.

Where duct connections are made on double width fans, static pressure on both inlets must be carefully balanced; otherwise, the fans may be over or under capacity. Inlet connections on double width fans necessitate the driving arrangement on the outside with extended shafts and outboard pedestals. It is not considered good practice to drive the belt through duct connections.

In selecting the discharge and rotation of the fan, the design of the duct should be continuous with the fan scroll, as in Figs. 6 and 7 which show the proper and improper rotation for connecting fan to duct work.

DESIGNATION OF FANS[1]

This method of designation will apply to all centrifugal fans, single or double width, and single or double inlet. Do not use the word "hand," but specify "clockwise" or "counter-clockwise."

Facing the driving side of the fan, blower or blast wheel, if the proper direction of rotation is clockwise, the fan, blower or blast wheel will be designated as *clockwise*. If the proper direction of rotation is counter-clockwise, the designation will be *counter-clockwise*. (The driving side of a single inlet fan is considered to be the side opposite the inlet regardless of the actual location of the drive.)

The discharge of a fan will be determined by the direction of the line of air discharge and its relation to the fan shaft, as follows:

Bottom horizontal.—If the line of air discharge is horizontal and below the shaft.

Top horizontal.—If the line of air discharge is horizontal and above the shaft.

Up blast.—If the line of air discharge is vertically up.

Down blast.—If the line of air discharge is vertically down.

All intermediate discharges will be indicated as angular discharge as follows:

Either top or bottom angular up discharge or top or bottom angular down discharge, the smallest angle made by the line of air discharge with the horizontal being specified.

ARRANGEMENT OF DRIVE

For the convenience of fan users, and to prevent misunderstandings which cause delays and losses the following suggestions are made for such arrangements of drive which are most often used. Reference to Arrangement 3 will be understood by all members of the Association as referring to accompanying Fig. 8 and description.

Arr. 1. For Belt Drive.

Single fan. Wheel overhung. Includes housing, wheel, shaft, two bearings, pedestal and pulley.

Arr. 3. For Belt Drive.

Single fan. Pulley overhung. Includes housing, wheel, shaft, two bearings and pulley.

Arr. 4. For Direct Connection.

Single fan. Includes housing, wheel and base. Wheel is overhung on engine or motor shaft.

[1] Recommendations adopted by the *National Association of Fan Manufacturers.*

Arr. 5. For Direct Connection.
Single fan. Includes housing, wheel, shaft, bearing on drive side of fan, flanged coupling and base.

Arr. 6. For Direct Connection.
Single fan. Includes housing, wheel, shaft, bearing in fan inlet, flanged coupling and base.

Arr. 7. For Direct Connection.
Single fan. Includes housing, wheel, shaft, two bearings, flexible coupling and base.

Arrangement 1. Fan is of the overhung wheel type with the two bearings mounted on one side and the driving pulley in between. Arrangement 1 is preferred where the

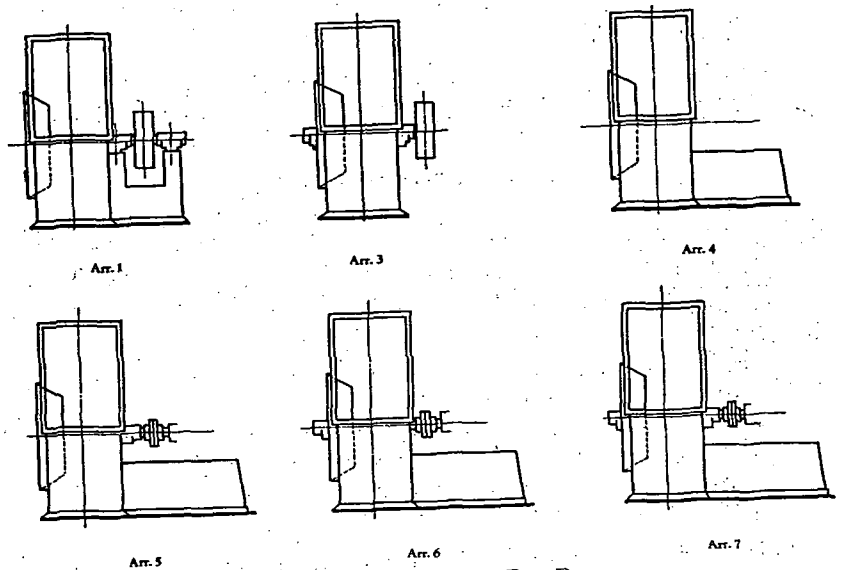


FIG. 8. ARRANGEMENT OF FAN DRIVE

fan exhausts from shafts making the inlet bearing inaccessible. It is also used for high temperatures and other conditions where it would be impossible to locate the bearing in the fan inlet.

Arrangement 3. Is the commonly used fan as it is furnished with a bearing on each side with wheel supported in the center. This fan is arranged for driving with belt which permits the use of high-speed efficient electric motors which can be purchased at a low initial cost. Arrangement 3 can be purchased at a lower initial cost than any other type shown.

Arrangement 4. Fan is used for practically all direct connected work. The fan motor is mounted directly on the motor shaft, the rotor being mounted on pedestal built integral with the fan housing, both motor bearings being easily accessible.

Arrangements 5, 6 and 7. Are used in larger fans where the fan motor is of such weight as to not permit it being suspended on an extended motor shaft.

STANDARD TEST CODE

All fans should be tested and guaranteed in accordance with The Standard Test Code for Disc and Propeller Fans, Centrifugal Fans and Blowers as adopted by the AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS and the *National Association of Fan Manufacturers.*

CHAPTER XXVII

MOTIVE POWER AND CONTROLS FOR FANS

Different Kinds of Motor Drives, Data on Steam, Power, Noise Prevention, Systems of Hand and Automatic Control, Remote Control.

TO make a proper selection of motors for heating, ventilating, drying, air conditioning, exhaust and collecting systems is an important function of an architect's and engineer's work in producing a plant that is efficient and economical. Points to be discussed briefly are fan characteristics, motor selection, methods of drive and general requirements of control as well as other power sources and sound deadening methods.

FAN MOTIVE POWER

Motive power for fans should be determined in accordance with the Standard Code of the AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS, TRANSACTIONS, Vol. 29, 1923; p. 442.

Fans divide themselves into two general classes; the disc or propeller type, and the centrifugal type.

Disc and Propeller Fans

The disc or propeller type of fan is available for conditions of low air resistance, with very short ducts, or no ducts at all. The low speed of the blades near the hubs, compared with the relatively high peripheral speed renders this entire class of fans of low efficiency when overcoming heavy resistance. The air driven by the more effective blade areas near the rim can pass back through the less effective blade areas at the hub more easily than it can overcome the duct-resistance. The power required for such fans increases with the cube of the speed as the speed is increased, and the static efficiency curve falls rapidly at any given speed when the resistance to air flow is increased.

Disc and propeller fans lend themselves to direct-connected motive power, especially as the speeds may be high enough for economical electric motor speeds.

In specifying direct connected electric motors for these fans it should always be remembered that the motor will be subject to the dust and possible high temperature of the material handled by the fan.

Enclosed and specially cooled electric motors are available for this service, and in many types the fan is suspended on the motor shaft.

Centrifugal Fans

The centrifugal, housed type of fan is available for conditions of high air resistance, with heaters, ducts, etc., and is used for systems requiring from one-fourth to two inches or more of water pressure to overcome the air friction.

Material for this section prepared especially for THE GUIDE by S. R. Lewis.

The power required for such fans is proportional to the volume of the air moved, and to the pressure overcome. Centrifugal fans with radial or forward-curved blades require power proportional to the volume at constant speed and have a power increase as the cube of the speed. If the resistance is increased the air volume is reduced, and the power at constant speed is reduced. If the resistance is reduced the air volume is increased at constant speed, and the power demand will be increased.

Centrifugal fans with backward-curved blades and those with compound curves while following the same general laws as the fans with the forward-curved blades, have been developed to the extent that they have a self-limiting power demand at a certain peripheral velocity even though the resistance at that speed may be decreased.

It is no easy matter to predetermine the exact resistance to be encountered by a fan, or having determined this resistance, to insure that no changes in construction or operation shall ensue which may increase air resistance, thus requiring more fan speed and power to deliver the required volume, or which may reduce air resistance, thus causing delivery of more air and a consequent increase of power even at constant speed.

It is recommended therefore for centrifugal type fans that the rated power to be supplied shall exceed the rated fan power by a liberal margin, depending on the type of blade, of from 10 per cent minimum, to about 25 per cent maximum.

Justification for liberal power provision exists also in the possibility of varying demand due to changes in ventilation requirements, intensity of occupation, weather conditions, etc.

Speed Control

Some method of volume control of fans usually is desirable. This may be done by varying the peripheral velocity, or by interposing resistance, as by throttling-dampers. Both methods, since they reduce the volume of air, reduce the power required. In many installations adjustments of volume are desirable during varying hours of the day. In others an increased supply of air in summer over that needed for winter, is demanded. There is room for judgment in deciding whether speed-control or damper-control shall be used for specific cases. Where noise is a factor, it may be exceedingly desirable to reduce the speed at times, while on the other hand a centrifugal fan which has its normal speed reduced as much as 50 per cent without change in resistance will move so small a volume of air that operating the fan will be hardly worth while.

Electric Motors

Electric power is the almost universal solution for fan operation, and each type of motor and current has its advantages and disadvantages.

Direct connected electric motors are usually very efficient for fan driving because there is no slippage due to belts, and no wear or noise due to chains or gears.

Unless the fan speeds are high enough to permit comparatively high rotative speeds, however, direct connected motors must be unduly large and heavy and will be costly. If anything goes wrong with a direct

connected motor there may be a considerable delay in replacing or repairing it, and changes in speed are not always made easily with full efficiency. On the other hand, the non-direct-connected motors have transmission subject to wear and slippage, and chains and gears may be noisy. With the latter type, however, changes in speed-ratio are easily made, and in case of a break-down a standard stock-motor may be substituted quickly.

Improved operating characteristics are obtained in the higher speed belted motors than in the slower speed direct connected motors. Efficiencies and power factors of alternating current higher speed motors are greatly improved over those of the slower speed motors. Quietness of operation in induction motors is more easily obtained in the higher speed machines. Magnetic noise is the chief offender because it is carried, and sometimes is amplified, by the steel work of a building. It is possible, however, to obtain motors especially designed for quiet operation, which will practically be free from objectionable noises. Even though these quiet operating motors shall be used the motor and fan still should be insulated from the foundation and the duct system should be broken and a suitable connection made by canvas or some non-metallic substance.

KINDS OF ELECTRICAL CURRENT

Direct current motors are extremely satisfactory for fan drive. Various kinds of speed-control can be obtained by the use of hand, semi-automatic or full automatic controllers.

Single phase, constant speed motors are satisfactory and available in sizes 10 hp. and smaller. Single phase adjustable speed motors (repulsion motors) in small sizes are available, but are satisfactory only when the load is always present. The repulsion single phase motor has an inherent characteristic of being subject to change of speed with a change in load. It should not, therefore, be used in driving centrifugal housed fans where there is any restriction in the fan line, such as a damper. Shutting off the air intake or air outlet from a centrifugal housed fan relieves the motor of the load and, with a repulsion single phase motor, the speed attained because of this light load would be objectionable from a noise standpoint and might do some damage to the fan wheel itself. With a propeller type of fan, the repulsion motor is quite satisfactory because if the air outlet is closed, load on the motor is still maintained.

Single phase motors require special starting devices, which are noisy and troublesome as compared with electric motors for direct current or polyphase current.

Polyphase motors are generally satisfactory for driving fans, though they are not adapted to exceedingly low speeds. It is seldom necessary to reduce the speed of a ventilating fan more than 50 per cent from the maximum fan speed and this feature is obtainable with alternating current motors by the use of hand, semi-automatic or full automatic controllers.

CONTROLLERS FOR ELECTRIC MOTORS

Very small direct current motors may be started by throwing them directly on the line through a suitable starting switch. The larger sizes require some type of starting device. When speed adjustment is desired,

the starting device and means for adjusting speed are usually incorporated in one controller.

Alternating current motors, 5 hp. and smaller, may usually be thrown directly on the line, unless local regulations may prevent.

Remote speed indicating controllers are available for operating fan motors. Speeds are changed by push-button stations, and small electric lamps indicate at what speed the fan is running. This type of control is very desirable in large buildings where the engineer is to have complete charge of the ventilating system. The push-button station may be located in the engineer's office, giving him complete control of the motor and indicating to him at what speed the various fans are running, or these push-button controls may be located in the spaces being ventilated, either with or without duplicate pilot lights in the engineer's office. Remote control may also be effected by pneumatic or by hydraulic apparatus.

Fan speeds generally are constant unless changes in the weather require corresponding variations. There is available a dial switch controller which can be pre-set manually for any speed desired and which after having been so pre-set will operate to control the motor indefinitely, in connection with the push-button. The dial switch may be located either at the remote station or near the fan.

Arrangements can be made for remote control of fan motors, or for automatic control by influence of temperature. Remote control may be by pneumatic or by hydraulic manipulation as well as by electrical means.

In many large ventilating systems which have heating plants in connection, steam engines are used to operate fans. A medium-speed steam engine, exhausting at low pressure into the radiators which heat the building or which warm the air, is a very economical source of power, is nearly noiseless, and has a wide range of speed variation. The steam-economy of such an engine usually is of little importance, since the engine serves as an auxiliary to the pressure-reducing valve interposed in such cases between the boiler and the radiators.

Internal combustion engines and line shafting are often used for fan driving, requiring clutches or shift-belts with loose pulleys in order to secure proper starting and control.

Control of Noise from Fan Motive Power

Experience seems to indicate that noise is largely eliminated by isolation of foundations. The best practice is to bolt the fan and motor rigidly to substantial foundations of concrete or wood, to give inertia and solidity, and to float this foundation above a yielding, inert non-resonant buffer of cork or dry sand, with arrangements to prevent any side motion by interposing similar side-buffers.

It is sometimes necessary to sound-insulate the walls of the machinery room. The best practice for this purpose is cork, felt or other sound absorbing material against the walls, faced with sheet metal, the metal being isolated from direct contact with the building structure, or it is better still to use some porous and non-resonant material instead of the sheet metal.

All duct connections to fans should be made with canvas or other non-sound transmitting materials.

CHAPTER XXVIII

AIR DUCT DESIGN AND CONSTRUCTION

Air Velocities, Properties of Air, Pressure Losses, Proportioning Ducts, Construction Data.

THE successful operation of a mechanical or plenum heating installation, an exhaust system or a dust collecting plant is largely dependent upon the correct design of the duct system. Materials, proportions, friction, location and innumerable other items are factors in the correct operation of a duct system.

In the design of ducts and flues for gravity or mechanical circulation of air, losses due to friction are the basis for figuring and these losses must be kept within the available pressure difference. This pressure difference in mechanical ventilation is that derived from the fan, while in gravity ventilation it is the aspirating effect due to the temperature and height of the column of heated air.

When attempting the design of a duct system the general rules to remember are:

1. The air should be conveyed as directly as possible at reasonable velocities to obtain the result desired with greatest economy of power, material, and space.

2. Sharp elbows and bends are to be avoided.

3. All ducts or flues shall have sides as nearly equal in size as possible. (In no case shall the ratio between long and short sides be greater than 10 to 1.)

The piping systems for various operations must be of different design as the principal consideration for industrial work is for heating while in public buildings the air required for ventilation greatly exceeds the volume needed for heating. For instance, the ducts for a school, theatre or other public building, where freedom from noise and elimination of drafts is essential and where branch ducts serve individual rooms, present more difficult problems in design than are involved in proportioning ducts intended for heating a factory, where a main duct of decreasing dimensions extends lengthwise of the building and gives a uniform distribution of air. For public buildings air velocities must, therefore, be kept low between 900 and 1200 ft. per minute while in industrial buildings they can range from 1500 to 2000 ft. per minute or even more with no other disadvantage than expensive operation.

Material for this Chapter especially prepared for THE GUIDE by A. A. Criqui.

Table 1. Corresponding Pressures and Velocities of Dry Air at 70 Deg. and 29.92 In. Barometer

Inches of Water	Ounces per Sq. In.	Velocity Ft. per Min.	Inches of Water	Ounces per Sq. In.	Velocity Ft. per Min.
0.05	0.0289	896	4.77	2.750	8745
0.10	0.577	1266	5.00	2.884	8943
0.20	0.1154	1791	5.20	3.000	9134
0.25	0.1443	2003	5.50	3.172	9392
0.30	0.1730	2193	6.00	3.460	9810
0.40	0.2308	2533	6.07	3.500	9864
0.43	0.2500	2637	6.50	3.749	10210
0.50	0.2884	2832	6.94	4.000	10545
0.60	0.3460	3102	7.00	4.037	10595
0.70	0.4037	3351	7.50	4.326	10968
0.75	0.4326	3468	7.80	4.500	11187
0.80	0.4614	3582	8.00	4.614	11328
0.87	0.5000	3729	8.67	5.000	11792
0.90	0.5190	3800	9.00	5.190	12015
1.00	0.5768	4005	9.54	5.500	12367
1.25	0.7209	4478	10.00	5.768	12665
1.30	0.7500	4566	10.40	6.000	12915
1.50	0.8650	4905	11.00	6.344	13282
1.73	1.0000	5273	11.27	6.500	13445
1.75	1.0092	5298	12.00	6.921	13875
2.00	1.1535	5664	12.14	7.000	13950
2.17	1.2500	5895	13.00	7.497	14440
2.25	1.2975	6007	13.87	8.000	14913
2.50	1.4418	6332	14.00	8.074	14985
2.60	1.5000	6457	15.00	8.650	15510
2.75	1.5860	6641	15.61	9.000	15820
3.00	1.7300	6937	16.00	9.227	16020
3.03	1.7500	6976	17.00	9.805	16513
3.25	1.8740	7220	17.34	10.000	16675
3.47	2.0000	7457	18.00	10.380	16990
3.50	2.0185	7492	19.00	10.960	17456
3.75	2.1630	7756	19.07	11.000	17488
3.90	2.2500	7910	20.00	11.535	17910
4.00	2.3070	8010	20.81	12.000	18265
4.25	2.4510	8256	22.54	13.000	19012
4.34	2.5000	8337	24.28	14.000	19730
4.50	2.5950	8496	26.01	15.000	20420
4.75	2.7395	8729	27.74	16.000	21090

Corresponding Velocity for Dry Air at Various Pressures and Temperatures and 29.92 In. Barometer

Pressure		50°	60°	70°	100°	150°	300°	500°	550°
Inches	Ounces								
0.25	0.1443	1965	1986	2003	2059	2149	2399	2696	2895
0.5	0.2884	2778	2808	2832	2911	3038	3391	3812	4095
0.75	0.4326	3402	3439	3468	3565	3720	4153	4668	5020
1.00	0.5768	3929	3971	4005	4117	4296	4796	5390	5795
1.25	0.7209	4393	4440	4478	4602	4804	5362	6027	6470
1.50	0.8650	4812	4864	4905	5042	5262	5874	6602	7100
1.75	1.0092	5197	5254	5298	5446	5683	6344	7131	7655
2.00	1.1535	5556	5616	5664	5822	6076	6783	7624	8195
2.25	1.2975	5892	5956	6007	6174	6443	7193	8085	8690

Standard velocities of air in public buildings are as follows:

1. Through the outside air intakes 1000 ft. per minute.
2. Through connections to and from heater 1000 to 1200 ft. per minute.
3. Through the main discharge duct from 900 to 1200 ft. per minute.
4. In branch ducts 600 to 1000 and vertical flues 400 to 800 ft. per minute.
5. In registers or grilles 200 to 400 ft. per minute depending upon the size and location.
6. If diffusers of proper design are used, 25 per cent higher air velocities may be permitted.

It is customary in proportioning ducts for heating and ventilating work to follow either of two methods:

1. Arbitrarily select sizes from assumed velocities, depending upon velocity of air at fan outlet.
2. Determining the velocity which will give an assumed resistance within fan capacity at noiseless operating speed.

By decreasing the velocity in main duct as air is delivered through branch outlets: (1) more uniform air delivery through outlets is accomplished, (2) friction in smaller pipes is reduced, (3) portion of velocity head is converted into static pressure.

FRICTION LOSSES IN PIPES

The two greatest losses in duct systems are dynamic losses and friction losses. The former are chiefly caused by changes in direction or in velocity of air flow and are expressed as pressure in inches of water gage—see Table 1.

The loss of head caused by friction, which is numerically equal to the pressure required to maintain a given velocity, may be most easily expressed by the modification of the Fanning formula, when, dealing with round pipe and standard air (70 deg. fahr. — 29.92 Bar).

$$h = f\frac{L}{D}h_v = \frac{L}{CD}\left(\frac{V}{4005}\right)^2 \qquad 1$$

When dealing with rectangular ducts and standard air,

$$h = f\,L\left(\frac{a+b}{2ab}\right)h_v = \frac{L}{C}\left(\frac{a+b}{2ab}\right)\left(\frac{V}{4005}\right)^2 \qquad 2$$

where

h = loss of head in inches of water.
V = velocity of air in feet per minute.
L = length of pipe.
D = diameter of pipe.
a = one side of rectangular duct.
b = other side of rectangular duct.
} All in feet or inches.
f = coefficient of friction which varies from about 0.01 to 0.03.
C = length of pipe in diameters for one head loss.

For most calculations it will simplify matters to consider that the value of f and C vary only with the nature of the pipe surface. Thus, C may be taken as about 60 for smooth piping, such as used in planing mill exhaust systems; $C = 50$ for ordinary galvanized iron heating and ventilating

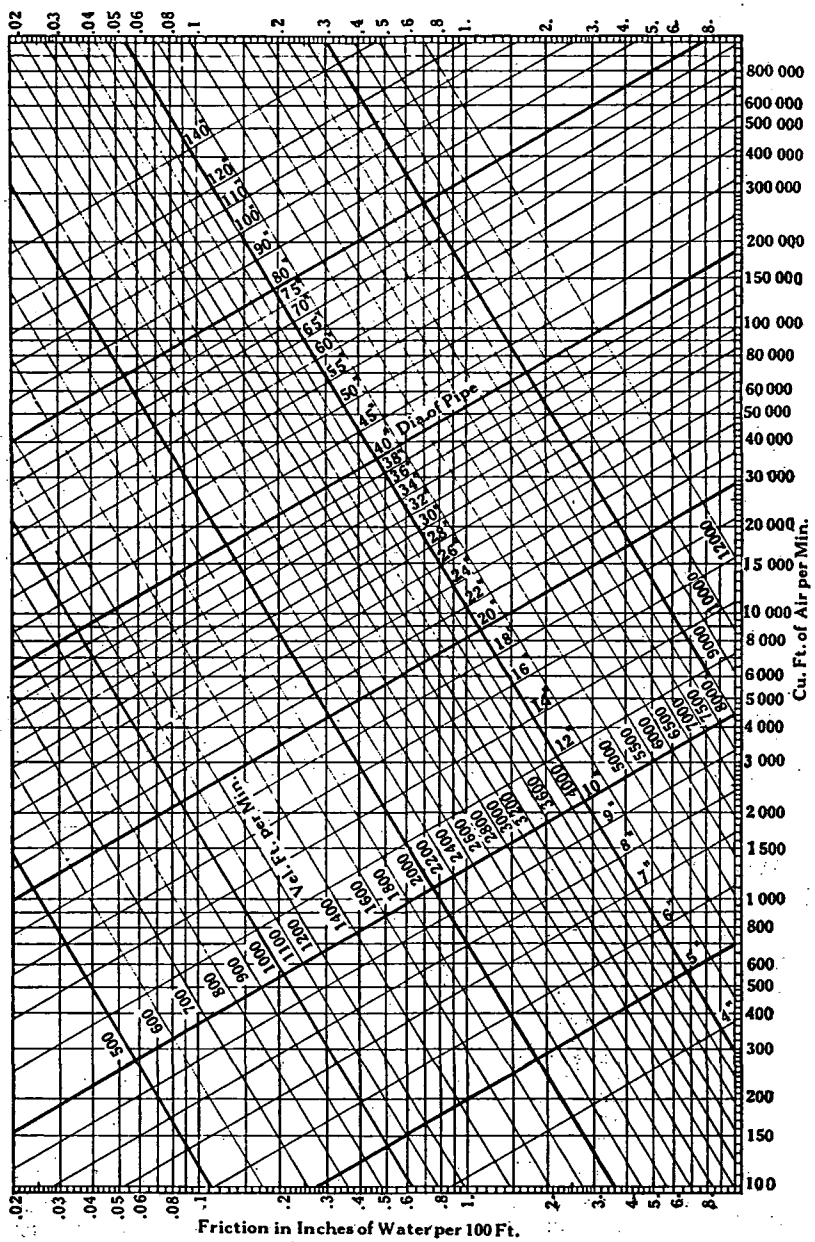


FIG. 1. FRICTION OF AIR IN PIPES

TABLE 2. CIRCULAR EQUIVALENTS OF RECTANGULAR DUCTS FOR EQUAL FRICTION

Side Rectangular Duct	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
8	6.9	7.6	8.2	8.8																
9	7.3	9.0	8.7	9.3	9.9															
10	7.7	8.4	9.2	9.8	10.4	11.0														
11	8.0	8.8	9.6	10.2	10.9	11.5	12.1													
12	8.3	9.2	10.0	10.7	11.4	12.0	12.6	13.2												
13	8.7	9.6	10.4	11.1	11.8	12.5	13.1	13.7	14.3											
14	8.9	9.9	10.8	11.5	12.3	12.9	13.6	14.3	14.9	15.4										
15	9.2	10.2	11.1	11.9	12.7	13.4	14.1	14.7	15.3	16.0	16.5									
16	9.5	10.5	11.4	12.3	13.1	13.8	14.5	15.2	15.8	16.5	17.1	17.6								
17	9.8	10.8	11.8	12.6	13.5	14.2	15.0	15.7	16.3	17.0	17.6	18.2	18.7							
18	10.0	11.1	12.1	13.0	13.8	14.6	15.4	16.1	16.8	17.4	18.1	18.7	19.2	19.8						
19	10.3	11.4	12.4	13.3	14.2	15.0	15.8	16.5	17.2	17.9	18.6	19.2	19.8	20.4	20.9					
20	10.5	11.6	12.7	13.6	14.5	15.4	16.2	17.0	17.6	18.4	19.0	19.7	20.3	20.9	21.5	22.0				
22	11.0	12.1	13.2	14.2	15.2	16.1	16.9	17.8	18.5	19.2	19.9	20.6	21.3	21.9	22.5	23.1	23.6			
24	11.4	12.6	13.8	14.8	15.8	16.8	17.6	18.5	19.3	20.0	20.8	21.5	22.2	22.8	23.5	24.0	24.7	25.2	25.9	26.4
26	11.8	13.1	14.3	15.4	16.4	17.3	18.3	19.2	20.0	20.8	21.6	22.3	23.0	23.8	24.4	25.1	25.7	26.3	26.9	27.5
28	12.2	13.5	14.8	15.9	17.0	18.0	19.0	19.8	20.7	21.5	22.4	23.1	23.9	24.6	25.3	26.0	26.6	27.3	27.9	28.5
30	12.6	13.9	15.2	16.4	17.5	18.5	19.5	20.5	21.4	22.2	23.1	23.9	24.7	25.4	26.2	26.8	27.5	28.2	28.8	29.5
32	12.9	14.3	15.6	16.9	18.0	19.1	20.1	21.1	22.0	22.9	23.8	24.6	25.4	26.2	27.0	27.7	28.4	29.1	29.8	30.5
34	13.2	14.7	16.1	17.3	18.5	19.6	20.7	21.6	22.6	23.5	24.4	25.3	26.2	26.9	27.7	28.5	29.2	30.0	30.7	31.3
36	13.6	15.1	16.4	17.7	19.0	20.1	21.2	22.2	23.2	24.2	25.1	26.0	26.8	27.7	28.5	29.3	30.0	30.8	31.5	32.2
38	13.9	15.4	16.8	18.2	19.4	20.6	21.7	22.8	23.8	24.8	25.8	26.7	27.5	28.4	29.2	30.0	30.8	31.5	32.3	33.1
40	14.3	15.7	17.2	18.6	19.8	21.1	22.2	23.3	24.4	25.4	26.4	27.3	28.2	29.1	29.9	30.8	31.6	32.4	33.1	33.9
42	14.5	16.1	17.6	19.0	20.3	21.6	22.7	23.8	24.9	25.9	26.9	27.9	28.8	29.8	30.7	31.4	32.2	33.0	33.8	34.5
44	14.8	16.4	18.0	19.4	20.7	22.0	23.1	24.3	25.4	26.5	27.5	28.5	29.5	30.3	31.2	32.1	32.9	33.7	34.5	35.3
46	15.1	16.7	18.4	19.8	21.1	22.4	23.6	24.8	25.9	27.0	28.1	29.1	30.1	31.0	31.9	32.8	33.8	34.6	35.4	36.2
48	15.4	17.0	18.7	20.1	21.5	22.8	24.1	25.2	26.4	27.5	28.6	29.6	30.5	31.6	32.5	33.4	34.3	35.2	36.1	37.0
50	15.7	17.3	19.0	20.4	21.9	23.2	24.5	25.7	26.9	28.0	29.2	30.3	31.3	32.2	33.1	34.1	35.0	35.9	36.8	37.6
52	15.9	17.6	19.2	20.8	22.2	23.6	24.9	26.2	27.4	28.5	29.6	30.7	31.8	32.9	33.8	34.7	35.6	36.5	37.4	38.3
54	16.1	17.9	19.6	21.1	22.6	24.0	25.3	26.6	27.8	29.0	30.1	31.2	32.3	33.4	34.4	35.3	36.3	37.2	38.0	38.9
56	16.3	18.2	19.9	21.5	22.9	24.4	25.7	27.0	28.3	29.5	30.6	31.7	32.8	33.9	34.9	35.9	36.9	37.8	38.7	39.6
58	16.6	18.4	20.2	21.8	23.3	24.7	26.1	27.4	28.7	30.0	31.1	32.2	33.3	34.4	35.4	36.4	37.4	38.4	39.4	40.3
60	16.8	18.7	20.4	22.1	23.6	25.1	26.5	27.8	29.1	30.5	31.6	32.7	33.8	34.9	36.1	37.1	38.1	39.1	40.0	40.9
62	17.0	19.0	20.7	22.4	24.0	25.5	26.9	28.2	29.5	30.9	32.1	33.2	34.3	35.4	36.6	37.7	38.7	39.6	40.6	41.6
64	17.3	19.2	21.0	22.7	24.3	25.9	27.3	28.6	29.9	31.3	32.6	33.7	34.8	35.9	37.1	38.2	39.2	40.2	41.2	42.2
66	17.5	19.5	21.2	23.0	24.6	26.2	27.7	29.0	30.3	31.7	33.0	34.2	35.3	36.4	37.6	38.7	39.8	40.8	41.8	42.8

TABLE 2. CIRCULAR EQUIVALENTS OF RECTANGULAR DUCTS FOR EQUAL FRICTION—(Continued)

SIDE RECTANGULAR DUCT	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	42	44	46	48
26	28.1	28.6																		
28	29.1	29.7	30.2	30.8																
30	30.1	30.7	31.3	31.9	32.5	33.0														
32	31.1	31.7	32.3	32.9	33.5	34.1	34.6	35.2												
34	32.0	32.7	33.3	33.9	34.5	35.1	35.7	36.3	36.8	37.4										
36	32.9	33.7	34.3	34.9	35.5	36.1	36.7	37.3	37.9	38.5	39.1	39.6								
38	33.8	34.6	35.3	35.9	36.5	37.1	37.7	38.4	39.0	39.5	40.1	40.7	41.2	41.8						
40	34.6	35.3	36.0	36.7	37.4	38.0	38.6	39.3	39.9	40.5	41.1	41.7	42.3	42.9	43.4	44.0				
42	35.2	36.0	36.8	37.6	38.3	39.0	39.6	40.3	40.9	41.5	42.1	42.7	43.4	44.0	44.5	45.1	46.2			
44	36.1	36.9	37.7	38.5	39.2	39.9	40.5	41.2	41.8	42.5	43.1	43.7	44.3	44.9	45.5	46.1	47.2	48.4		
46	37.0	37.8	38.5	39.3	40.0	40.8	41.5	42.2	42.9	43.5	44.2	44.8	45.4	46.0	46.6	47.2	48.4	49.5	50.6	
48	37.8	38.5	39.2	40.0	40.8	41.5	42.3	43.0	43.7	44.4	45.0	45.6	46.3	46.9	47.5	48.1	49.3	50.5	51.6	52.8
50	38.4	39.2	40.0	40.8	41.5	42.3	43.0	43.8	44.5	45.2	45.9	46.5	47.1	47.9	48.5	49.1	50.4	51.6	52.9	54.0
52	39.1	40.0	40.8	41.6	42.3	43.1	43.9	44.7	45.4	46.1	46.8	47.5	48.2	48.9	49.5	50.1	51.3	52.5	53.8	55.0
54	39.8	40.7	41.5	42.4	43.2	44.0	44.7	45.5	46.4	47.0	47.6	48.4	49.2	49.9	50.5	51.1	52.3	53.5	54.8	56.0
56	40.4	41.3	42.1	43.0	43.8	44.6	45.4	46.2	46.9	47.7	48.5	49.1	49.9	50.6	51.3	52.0	53.3	54.6	55.9	57.0
58	41.2	42.1	42.9	43.8	44.5	45.4	46.2	47.0	47.8	48.5	49.4	50.0	50.8	51.5	52.2	52.9	54.2	55.5	56.8	58.0
60	41.8	42.7	43.6	44.5	45.4	46.1	46.9	47.8	48.5	49.3	50.1	50.9	51.6	52.3	53.0	53.8	55.0	56.4	57.7	58.9
62	42.5	43.4	44.3	45.1	46.0	46.8	47.6	48.4	49.3	50.0	50.9	51.7	52.4	53.0	53.9	54.5	55.9	57.2	58.5	59.7
64	43.1	44.0	44.9	45.8	46.7	47.5	48.4	49.2	50.0	50.9	51.7	52.4	53.2	53.9	54.7	55.4	56.8	58.1	59.4	60.6
66	43.7	44.7	45.6	46.5	47.3	48.2	49.1	50.0	50.7	51.6	52.4	53.1	53.9	54.7	55.5	56.2	57.6	59.1	60.4	61.6
68	44.4	45.3	46.3	47.2	48.0	48.9	49.7	50.7	51.4	52.2	53.1	53.8	54.6	55.5	56.2	56.9	58.4	59.9	61.3	62.6
70	45.0	46.0	46.9	47.8	48.7	49.5	50.4	51.3	52.0	52.9	53.7	54.5	55.4	56.2	57.0	57.7	59.1	60.6	62.1	63.5
72	45.5	46.5	47.5	48.4	49.3	50.1	51.0	51.9	52.8	53.7	54.6	55.4	56.2	57.0	57.8	58.7	60.0	61.3	63.0	64.5

TABLE 2. CIRCULAR EQUIVALENTS OF RECTANGULAR DUCTS FOR EQUAL FRICTION—(Continued)

SIDE RECTANGULAR DUCT	50	52	54	56	58	60	62	64	66	68	70	72	74	76	78	80	82	84	86	88
50	55.0																			
52	56.1	57.2																		
54	57.2	58.3	59.4																	
56	58.3	59.4	60.5	61.6																
58	59.3	60.5	61.6	62.7	63.8															
60	60.3	61.5	62.7	63.8	64.9	66.0														
62	61.3	62.5	63.7	64.8	66.0	67.1	68.2													
64	62.2	63.5	64.7	65.9	67.1	68.2	69.3	70.4												
66	63.2	64.4	65.7	66.9	68.1	69.3	70.4	71.5	72.6											
68	64.1	65.4	66.6	67.9	69.1	70.3	71.5	72.6	73.7	74.8										
70	65.0	66.3	67.6	68.8	70.1	71.3	72.5	73.7	74.8	75.9	77.0									
72	65.9	67.2	68.5	69.8	71.1	72.3	73.5	74.7	75.9	77.0	78.1	79.2								
74	66.8	68.1	69.4	70.7	72.0	73.3	74.5	75.7	76.9	78.1	79.2	80.3	81.4							
76	67.6	69.0	70.3	71.6	72.9	74.2	75.5	76.7	77.9	79.2	80.3	81.4	82.5	83.6						
78	68.4	69.8	71.2	72.6	73.9	75.2	76.4	77.7	78.9	80.2	81.4	82.5	83.6	84.7	85.8					
80	69.2	70.7	72.1	73.5	74.8	76.1	77.4	78.6	79.9	81.2	82.4	83.6	84.7	85.8	86.9	88.0				
82	70.1	71.5	73.0	74.4	75.7	77.1	78.4	79.6	80.9	82.1	83.4	84.6	85.8	86.9	88.0	89.1	90.2			
84	70.9	72.3	73.8	75.2	76.6	78.0	79.3	80.6	81.9	83.1	84.4	85.6	86.8	88.0	89.1	90.2	91.3	92.4		
86	71.7	73.2	74.6	76.0	77.4	78.9	80.3	81.5	82.9	84.0	85.3	86.6	87.8	89.0	90.2	91.3	92.4	93.5	94.6	
88	72.5	74.0	75.5	76.8	78.3	79.8	81.2	82.5	83.9	85.0	86.3	87.5	88.8	90.0	91.2	92.4	93.5	94.6	95.7	96.8
90	73.3	74.7	76.3	77.7	79.1	80.6	82.0	83.4	84.7	85.9	87.2	88.5	89.7	91.0	92.2	93.4	94.6	95.7	96.8	97.9
92	74.1	75.5	77.1	78.5	79.9	81.4	82.8	84.3	85.6	86.9	88.2	89.5	90.7	92.0	93.2	94.4	95.6	96.7	97.9	99.0
94	74.8	76.3	77.8	79.3	80.7	82.2	83.7	85.1	86.5	87.8	89.1	90.4	91.7	93.0	94.2	95.4	96.6	97.8	99.0	100.1
96	75.5	77.1	78.7	80.2	81.6	83.0	84.5	85.9	87.4	88.7	90.0	91.3	92.6	93.9	95.2	96.4	97.6	98.8	100.0	101.2

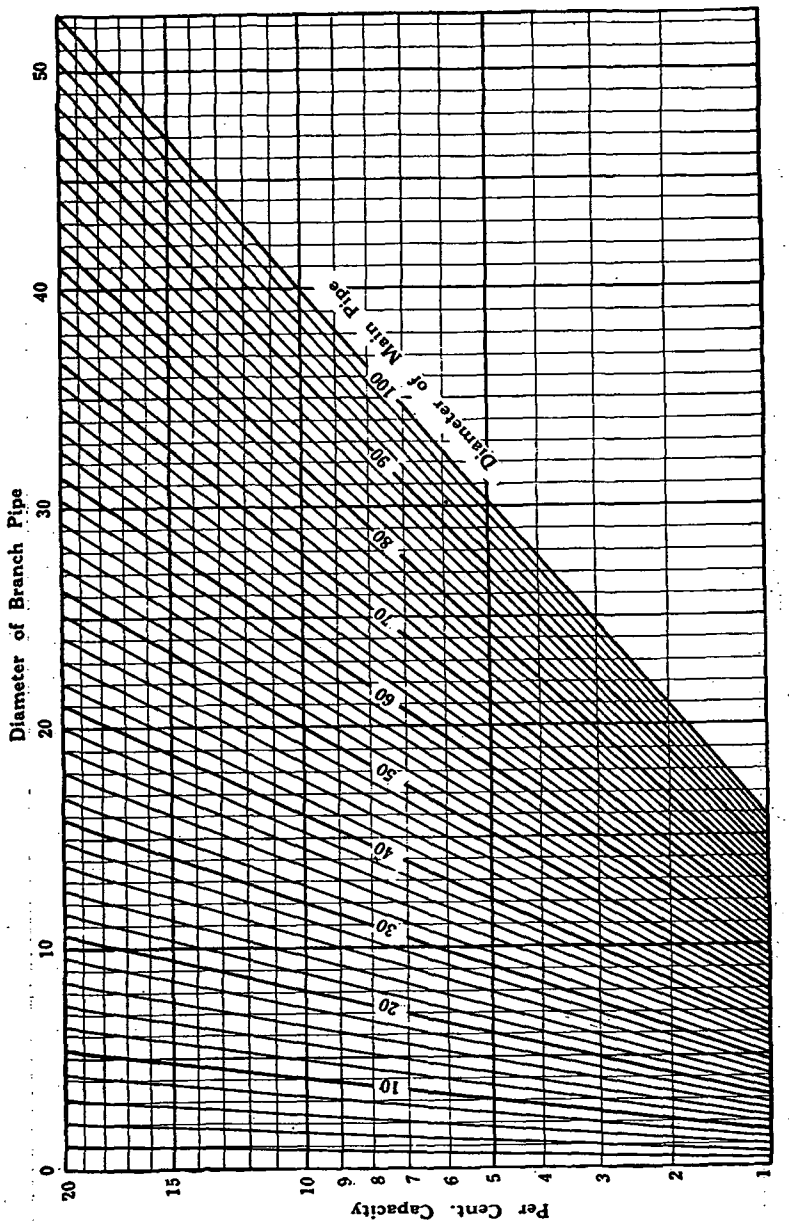


Fig. 2. Main and Branch Pipes for Equal Friction per Foot of Length

ducts; and $C = 45$ for smooth and 40 for rough conduits of tile, brick or concrete.

The value of f and C given, not only vary with the roughness of the inside surface of the pipe, but also with the diameter and velocity. The coefficient of friction f decreases with both increase of diameter and velocity. It should also be noted that the coefficient of friction varies directly with the air density and approximately inversely as the absolute temperature.

The chart shown (Fig. 1) will be found very convenient to determine the friction for a given air capacity in various size ducts at corresponding velocities. The coefficient of friction has been corrected for the various diameters and capacities, based on the rule that the coefficient of friction varies inversely as the 2/7 power of the diameter, and inversely as the 1/7 power of the capacity. This chart is based on a loss of one velocity head (at 2000 velocity) in a length equal to 50 diameters of 24-in. galvanized swedged pipe.

As an example of the use of the chart, assume that it is desired to pass 10,000 cu. ft. of air per minute through 75 ft. of 24-in. diameter pipe. Find 10,000 cu. ft. of air per minute on the right scale and move horizontally left to the diagonal line marked 24 in. The other intersecting diagonal shows that the velocity in the pipe is 3200 ft. per minute. Directly below the intersection it is found that the friction per 100 ft. is 0.59 in., then for 75 ft. it will be $0.75 \times 0.59 = 0.44$ in. In a like manner any two variables may be determined by the intersection of the lines representing the other two variables.

Other losses of pressure are at the entrance to the duct, through heater, air washer, etc. In ordinary practice it is usual to keep the sum of the piping losses ⅓ to ½ and the loss through heater at less than ½ of the static pressure. The remainder is then available for producing velocity.

The ideal duct system will take all factors into consideration and proportion air velocities so that the resistance will be practically equal in all ducts regardless of length.

Friction in Elbows

Experience has shown that with an elbow of radius $R = 1\frac{1}{2} D$ fairly good results may be obtained. The loss with such an elbow will be about 17 per cent of a velocity head for round ducts and about 8 per cent of a velocity head for square ducts. It has been found of little or no advantage in making an elbow or radius greater than two diameters. If, however, a smaller radius than $1\frac{1}{2} D$ be used, the losses increase rapidly. For instance, the loss for an elbow of $R = 1\ D$ will be as high as 17.5 per cent of a velocity head for a square duct and 25.5 per cent for round ducts.

For ordinary calculations one easy long radius elbow ($R = 1\frac{1}{2} D$) in a circular pipe may be considered as equal in friction loss to 10 diameters of straight pipe.

Proportioning the Size for Friction

It is often found convenient to size pipes for different capacities but having the same friction per foot of length. Such a system may be used in any supply system, and is advantageous from the point of view that the

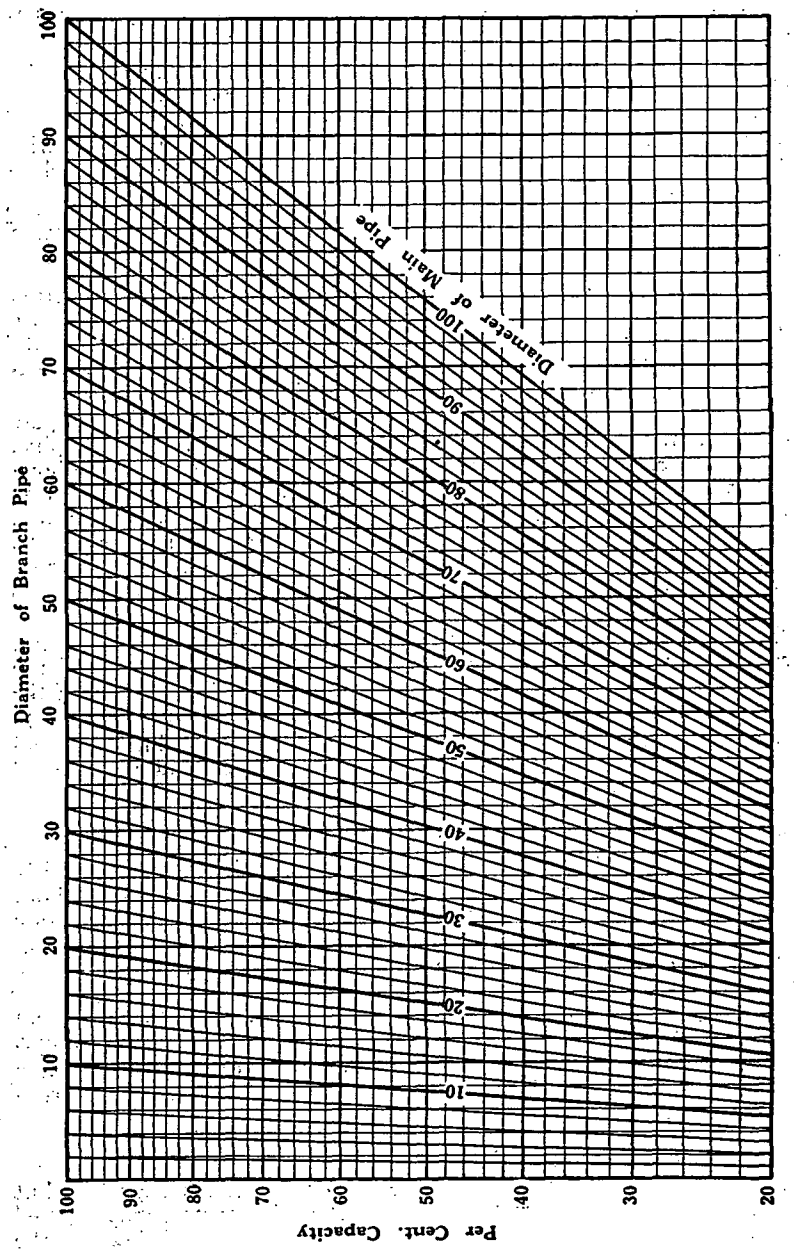


Fig. 3. Main and Branch Pipes for Equal Friction per Foot of Length

calculations are quickly made and a fairly uniform air distribution may be effected. By proper manipulation of charts shown (Figs. 2 and 3) the engineer may determine the diameter of branch pipes, to carry a given per cent of the total air in main pipe with the same friction per foot of length, for instance:

Suppose the main pipe is to be a 60-in., and it is desired to know the size of branch pipe to carry 50 per cent of total air in the main. Find 50 per cent at the left of the chart, move right to 60-in. diagonal line and note directly above at the top of the chart, that the branch pipe will be a 45.5 in. diameter.

Where rectangular ducts are used it is frequently desirable to know the equivalent diameter of round pipe to carry the same capacity and have the same friction per foot of length. The table on pages 425, 426, 427, gives directly the circular equivalent of rectangular ducts for equal friction and capacity.

To obtain the size of rectangular pipes for different capacities and having the same friction per foot of length, first obtain the equivalent round pipe for equal friction. Thus, suppose a branch to carry 30 per cent of a 12 x 36 in. pipe is wanted; from Table 2, it is found that the main is equivalent to a 22.2 diameter round pipe; from page 425, 30 per cent of this is a pipe 13.5 in. in diameter, and referring again to page 425, the rectangular equivalent branch is a 12 x 13 in., 10 x 15 in. or any other combination desirable.

Exhaust Systems

In design of piping for an exhaust system where no dampers are provided, it is considered good practice to make the area of the main pipe approximately 20 per cent greater than the sum of the areas of the branch pipes at that point. This method gives greater uniformity of distribution than where the increase in area is not made.

SOME GENERAL INSTALLATION AND CONSTRUCTION HINTS

1. For heating and ventilating work, ducts 6 x 6 in. represent a minimum size. In any place where other considerations do not outweigh, round pipe for small flues is recommended.

2. Abrupt turns or sharp bends should never be made. Elbows should have a throat radius equal to the depth of the duct.

3. Transformations and offsets should not be made abruptly. Angles greater than 45 deg. should be avoided. In any case, care should be taken not to restrict the true cross-sectional area.

4. Tees or branches from main ducts should make curved connections. Accessible and operative volume dampers should be used. Adjustable dampers should be provided with a means of indicating from the outside, the true position of the damper.

5. Access doors to ducts should be hinged and tightly fastened. Fire dampers in supply and vent ducts should be ⅛ in. steel plate, held by a fusible link for release at 160 deg. fahr.

6. Air intake should be screened with 1 in. mesh or less, at least No. 10 wire galvanized.

7. Final exit for exhaust discharges should be protected from the weather and pointed away from prevailing wind where possible.

8. Underground ducts should be water-proofed, provided with means of access for inspection and cleaning; also a drain connection trapped to sewer.

9. The use of varied metals and special finishes for different conditions encountered is of prime importance. The present day metal market affords wide range of choice, and a study of requirements for the individual application should be made.

10. Wherever moisture is present, either in the form of free water or a possibility of condensation occurring, galvanized iron sheets should always be used.

11. When service encountered is severe and the material used may be subjected to rapid deterioration, either from abrasion or excessive corrosion, heavier gages of materials than ordinarily used are recommended.

12. In exposed work the same method of formation should be used throughout. All visible work should present a neat and workmanlike appearance.

13. Accompanying table gives recommended gages of galvanized iron or steel sheets used for ducts, both rectangular and round:

ROUND DUCTS DIAMETER, IN.	GAGE U. S. STANDARD	RECTANGULAR DUCTS WIDTH, IN.
6 in. to 19 in.	No. 26 gage	4 in. to 18 in.
20 in. to 29 in.	No. 24 gage	19 in. to 30 in.
30 in. to 39 in.	No. 22 gage	31 in. to 60 in.
40 in. to 49 in.	No. 20 gage	61 in. to 118 in.
50 in. and above	No. 18 gage	120 in. and above

14. Methods of supporting and bracing rectangular ducts should be used so that sagging and buckling of sheets is entirely prevented. Hangers and angle iron stiffeners are recommended for ducts over 36 in. wide at intervals of 4 ft. 0 in.

15. For public building work ducts should be thoroughly braced to prevent vibration of sides.

16. Longitudinal seams and transverse joints should be flat and smooth inside. Slip joints should be in the direction of air flow.

The quantity, velocity, and pressure of air discharged by a fan or flowing through a pipe may be determined by various methods. An anemometer is used where accuracy is not required and where air velocities not over 600 ft. per minute are to be measured, as at registers. For the greatest measure of reliability the anemometer shall have been newly calibrated, and correction shall be made for the error as shown by the calibration.

The standard method for measuring air velocity and pressure shall be the Pitot Tube as described in the A. S. H. & V. E. Standard Code for the Testing of Centrifugal and Disc Fans (TRANS., A. S. H. & V. E., Vol. 29, 1923, p. 407.) Installation tests for determination of fan capacity and efficiency shall be under laboratory conditions, in accordance with this Code.

CHAPTER XXIX

AIR CLEANERS

Types of Air Cleaners, Air Washers, Temperature and Humidity Control, Steam Required for Air Washers and Humidifiers, Viscous Filters, Efficiency in Dust Removal.

IN the selection of a suitable air cleaning device the engineer is guided largely by the character and amount of the impurities to be removed. While almost every conceivable substance enters into the composition of dust, by far the most objectionable and destructive components are soot, flue dust, carbon and its related elements. The impurities in the air may be classified as dusts, fumes and smokes.

Dusts are particles which are large and heavy enough to fall with increasing rapidity due to gravity in still air. For instance, particles of flying sand or grit, such as are blown about on a windy day, the average diameter of which would be approximately 0.01 cm., are called dust.

Fumes are smaller particles which fall with constant velocity due to gravity in still air. The solid particles from atmospheric fog, for instance, are called fumes and have an average diameter in the neighborhood of 0.0014 cms.

Smokes are particles which do not settle at all in still air, which diffuse constantly, and which are actuated by the Brownonian motion rather than by gravity. An example of this type would be certain smokes, the average diameter of the particles of which is in the neighborhood of 0.0000015 cms.

The first attempt at air cleaning for general ventilation work was probably by the use of dry screens. Since ordinary Portland cement all passes a screen having 100 mesh to the inch, it is apparent that much dust may pass the finest mesh screen. When a screen as fine as this is moistened, not only the dirt ceases to pass but also the air passages clog up so that the filter becomes ineffective. Fine cloth filters were then tried and found very effective, except that they also clog up rapidly and soon become impervious to air. These considerations led many years ago to the development of the air washer types of air cleaners.

TYPES OF AIR WASHERS

Air washers are arranged to bring the air into contact with a large water area: (1) by passing it through a fine spray; (2) by passing it over

Material for this Chapter especially prepared for THE GUIDE by the following committee: H. C. Murphy, *chairman;* W. H. Carrier and F. B. Rowley.

wet surfaces; (3) by passing it both through a spray and over wet surfaces. After the air is washed it is freed from entrained water.

When air is cleansed by washing its humidity or moisture content is usually changed. In passing through the water spray or over the wet surfaces, both the dry and wet bulb temperature of the air approaches that of the water, at which temperature the air tends to become saturated. The moisture content of the air may, therefore, be controlled by controlling the water temperature. By using water at a temperature below the dew point temperature of the entering air the washer becomes a dehumidifier; or by heating the water to a temperature above the dew point of the entering air the humidity or moisture contents of the air may be increased. By raising the dry bulb temperature of the air after leaving the washer, its relative humidity may also be controlled. The humidifying efficiency of any air washer may be given as:

$$E = 1 - \frac{\text{Final wet bulb depression}}{\text{Initial wet bulb depression}}$$

for example: With an initial wet bulb depression of 20 deg. and the final wet bulb depression of 5 deg., the humidifying efficiency is

$$E = 1 - \frac{5 \text{ deg.}}{20 \text{ deg.}} = 0.75$$

The usual humidifying efficiency of a good air washer is 70 per cent. The humidifying efficiency of air washers of the commonly termed humidifier type should range from 95 to 98 per cent.

TEMPERATURE AND HUMIDITY CONTROL

Air washers require a method of control of temperature to prevent freezing by too low temperature, and to prevent over-humidification by too high temperatures of the air entering and leaving the washer. There are available one method of hand control and five methods of automatic or semi-automatic control. The method of hand control is by tempering heaters, divided into two or more sections in series; the outer section being turned on by hand whenever the outside temperature approaches freezing; the successive sections being turned on as the temperature drops below freezing. Where two sections are available it is usual to turn on the second section when the outside temperature goes below zero, and to turn on the third section, where necessary, at temperatures below zero. The first, or outside section must always be turned on full in cold weather to prevent freezing of the heaters. The steam supply to the second, or inside section, may be hand-regulated at all temperatures warmer than about 10 deg. above zero.

The five systems of automatic regulation are:

1. Substitution of automatic regulation for hand regulation, the automatic regulation being operated in a similar manner; the sections being controlled both by variations in the outside temperature conditions and by an auxiliary control for one inside section from a thermostat located on the discharge side of the air washer. (It is not possible ordinarily to control the temperature of the air entering the washer except where there

is an unusually long tunnel or duct for the thorough mixture of the air leaving the tempering heaters before it comes in contact with the thermostat.)

2. By heating the spray water so as to maintain a temperature or dew point (as the air is then saturated) of the air leaving the washer at between 35 and 40 deg. This method does not necessarily require a tempering heater. It is preferable, however, to use one section for the purpose of tempering the air should the washer be shut down, this to prevent freezing of the water when the apparatus is not in operation. More than one tempering section should never be used except where temperatures may go considerably below zero; then the tempering sections may be turned on, one at about 20 deg. fahr., and the second at about 0 deg. fahr. The tempering section may be operated manually or by a thermostat connected with the outside air. The steam supply for water heating should be sufficient to heat and saturate the air at from 10 to 35 deg. fahr., when water heating is used in conjunction with a tempering section. This is to allow a sufficient margin for safety of operation. The steam requirements for this are given later.

3. By regulating the heat supplied either through tempering sections or through the spray water so that the water in the tank shall be kept well above the freezing point. Inasmuch as the wet bulb temperature of the air and the water in the tank are but few degrees apart when the water in the tank is not heated directly, this method is a fairly effective and simple one. One permissible variation of this method is to use a thermostat in the air leaving the washer, controlling the dry bulb temperatures at this point through regulation of the steam supply to the inside tempering section. The wet bulb temperature of the air is controlled by means of water leaving the eliminator plates and is held at the desired point by means of adding heat to the spray water. This will control exactly the temperature and relative humidity of the leaving air. Two or more tempering sections are required for this method.

4. The fourth method is desirable where recirculation is used and consists in maintaining the temperature leaving the washer at about 40 deg. by means of a thermostat located at this point and controlling the admixture of fresh and return air through automatically operated dampers. This prevents over-humidification, eliminates danger of freezing, and effects the highest economy in cost, as no steam is required for either tempering or humidifying except after the air has passed the washer.

5. The fifth method of automatic control is to reheat the air leaving the air washer to a definite thermostatically controlled temperature, and to control the relative humidity of the air by means of a hygrostat which operates either on the tempering sections to heat the air or which controls a water heater for the spray water.

STEAM REQUIREMENTS FOR HEATING AND HUMIDIFYING AIR

Where the spray water is not heated it is necessary that the wet bulb temperature of the incoming air be above the freezing point; otherwise the eliminator plates will coat with ice and stop up, even if the dry bulb temperature of the leaving air is above the freezing point. It is necessary to heat zero air to 48 deg. in order that the wet bulb temperature may be 35 deg. The temperature of the leaving air may then be expected to be approximately 39 deg. dry bulb and 35 deg. wet bulb, with a dew point of 31 deg. The additional heat required due to humidification is that indicated by the temperature drop of 9 deg., or 162 B.t.u. per 100 cu. ft. of air, or 1 b.hp. for every 3400 cu. ft. of air per minute.

These are the minimum requirements for humidification, above those required for heating the air. The following Table 1 gives the heat required, from various outside entering wet bulb temperatures, to various dew point temperatures corresponding to various relative humidities at 70 deg.

These values are the total heat required for both heating and humidifying the air. The amount of heat required for humidifying only may be found by subtracting from the values given the heat required to

TABLE 1. HEAT REQUIRED TO RAISE 1000 CU. FT. OF AIR FROM VARIOUS OUTSIDE ENTERING WET BULB TEMPERATURES TO VARIOUS DEW POINT TEMPERATURES AND CORRESPONDING RELATIVE HUMIDITIES AT 70 DEG. FAHR.

See Marks' Engineers Handbook.

WET BULB TEMPERATURE OF ENTERING AIR, DEG. FAHR.	RELATIVE HUMIDITY, PER CENT AT 70 DEG. FAHR. (AND DEW POINT, DEG. FAHR.)					
	30% (37.25)	40% (44.5)	50% (50.5)	60% (55.3)	70% (59.6)	80% (63.5)
−10	1194	1452	1653	1860	2044	2245
0	984	1246	1447	1663	1840	2039
10	750	1025	1228	1445	1621	1822
20	510	779	983	1200	1377	1581
30	300	496	700	920	1097	1300
40	-----	178	384	603	783	987
50	-----	-----	-----	220	394	619
60	-----	-----	-----	-----	-----	181

raise the temperature of 1000 cu. ft. of air per minute between the limits specified. The heat required for heating the air is given by the formula

$$H = 1000\,\frac{t_2 - t_1}{55.5}$$

where H = B.t.u. required to raise 1000 cu. ft. of air from a temperature of t_1 to a temperature of t_2 deg. fahr.

AIR FILTERS

Air filters are distinguished from air washers in that they clean the air without the use of water and without the addition of a water spray. They are usually of the following types:

1. The viscous filter, depending upon the dirt impinging on a surface covered with a viscous fluid or oil.

2. The dry filter, which removes the dirt from the air by straining or filtering it through cloth, felt or paper screens, the openings in which are too small to allow the passage of dirt, or which removes the dirt by passing the air through tortuous passages.

VISCOUS AIR FILTERS

All of the so-called viscous type air filters operate on the principle of *adhesive impingement.* Investigation has shown that the dirt and dust in air, including the soot and carbons—the great destructive elements in modern ventilation work—are trapped and retained by successive impingements on oil coated surfaces. This is not a new idea—for years roads and floors have been oiled to keep the dust from flying about. Considerable ingenuity, however, has been shown in the various arrangements of metallic surfaces which are formed into filter units and made available for air cleaning work.

While the arrangement of filtering media and the kind of materials used are almost unlimited, there are certain rather definite requirements

for a practical commercial filter, and these have limited the possible constructions.

To fulfill the essential requirements of clean air an air filter must:

1. Be efficient in dirt removal.
2. Interpose low resistance to air flow.
3. Have a large dust holding capacity.
4. Be easy to clean and to handle.

There are other factors of importance, of course, among them weight, strength and permanency.

In order to secure maximum efficiency, it is necessary to divide the air into innumerable fine streams; the more intimately and frequently the air is brought into contact with the viscous-coated media the better the

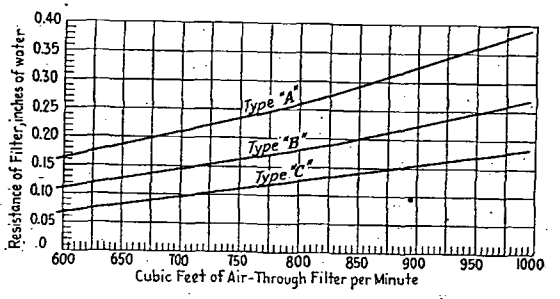


FIG. 1. RESISTANCE TO AIR-FLOW OF A TYPICAL UNIT AIR FILTER

cleaning will be. Theoretically seven impingements are sufficient; more will give better service.

As the dirt and dust are leached out of the air and collected on the adhesive coated surfaces, additional supplies of binding liquid are required in order to bind further layers of dirt. For this reason filters are usually designed to hold somewhere within the unit additional supplies of the binding liquid, capable of distribution by capillary attraction, or by some mechanical means.

Investigations in this country and abroad demonstrate that the first impingement of dust-laden air on a viscous coated surface removes 60 per cent of the dust, the next impingement takes 60 per cent of what then remains—that is, 24 per cent—the next impingement removes 9.6 per cent, etc. The principle of progressively packed media is embodied to a greater or less extent in all unit viscous filters. This arrangement gives relatively large spaces for the collection of dirt in the front part of the filter, where the bulk of the solids are taken out, without undue increase in resistance. At the back of the filter the openings are smaller and finer dust particles are removed.

The charging liquid used with these filters should be odorless, fire-proof, and germicidal in its action.

UNIT VISCOUS FILTERS

Unit viscous filters usually are made up of a number of separate filter units with a frame or frames designed to support them and arranged so that the filter units are easily removed from the frame for cleaning and recharging.

If the unit filters are cleaned "progressively" the resistance and volume of air delivered may be kept practically constant. By cleaning a predetermined number of filters every week—or every month, as the case may be, the resistance and consequent air volume can be held at any desired figure.

Obviously, the resistance and efficiency of a unit air filter of the adhesive impingement type depends upon the velocity at which the air

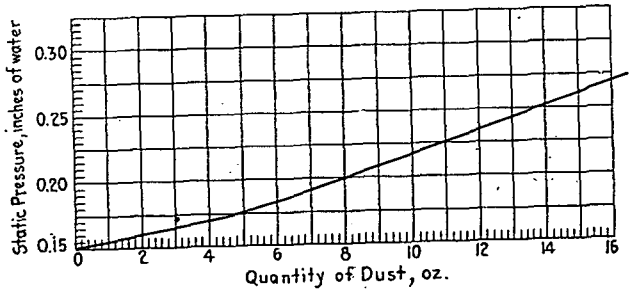


FIG. 2. CHART SHOWING CHANGE IN RESISTANCE DUE TO DUST ACCUMULATION

is handled and the condition of the unit—that is, whether the unit is clean or dirty.

The efficiency of the unit is usually highest after it has accumulated approximately 75 per cent of its maximum load of dirt—as the dirt and dust accumulated in the cell usually offer highly efficient media for the further collection of solids from the air.

The resistance of the commercial unit air filter of the adhesive impingement type varies from $\frac{1}{16}$ to $\frac{3}{8}$ in. water gage when clean, depending of course upon the design selected. As dust accumulates in the filter, the resistance and cleaning efficiency usually rises, charts Figs. 1 and 2.

Fig. 1 shows the resistance to air flow of a typical unit air filter, which is built in three types, having respectively $\frac{1}{8}$, $\frac{1}{4}$ and $\frac{3}{16}$ in. water gage resistance when operated at a velocity of approximately 365 lin. ft. per minute. Fig. 2 shows the change in resistance due to dust accumulation. Under actual operating conditions one pound of dust represents about eight weeks of normal service. The resistance of an installation of filters under the above conditions could be held at any point between 0.15 in., the resistance of a clean filter, and 0.27 in., the resistance after accumulating one pound of dust, by cleaning a sufficient number of cells each week to maintain the desired average.

To make sure of proper periodic cleaning of the units the installation of a standard draft gage is recommended.

Proper washing, drying and recharging equipment should be installed as convenient to each set of filter as possible.

AUTOMATIC VISCOUS FILTERS

Unit air filters have certain limitations in the amount of dirt which can be handled. If the dirt reaches the filter too rapidly, or in such quantities that the adhesive liquid does not have sufficient opportunity to soak through and wet the successive layers, the cleaning efficiency drops off. Removals for unit filter cleansing sometimes prove so frequent as to be objectionable or impracticable.

This fact, and perhaps the age-old effort to eliminate dependence where possible on the human element, brought forth the self-cleaning or automatic viscous filters, several distinct types of which are now available.

In the main these filters are based on the same fundamental principles as unit viscous filters. All utilize the principle of adhesive impingement. Various ingenious arrangements of struts, woven wires or foraminous metal sheets are arranged to move progressively through the bath of charging liquid, the dirt thus being flushed off, while in other types the filter media itself remains stationary, and the charging liquid moves over the dirt-collecting surfaces, flushing off the accumulated dirt at regular intervals, usually once in 24 hours.

DRY AIR FILTERS

There are now available various types of unit and automatic air filters in which the dust is impinged upon or filtered out through felt, cloth or paper screens. These devices require no adhesive liquid of any kind, but depend on the straining or screening action of the filter media. The filters are cleaned by rapping, by reversing the air flow or by supplying new filter areas.

EFFICIENCY IN DUST REMOVAL

The comparative efficiency in dust removal of various air-cleaning devices can be determined by means of standardized tests made with air at stated capacities and with dust of definite quantity and quality. There are a number of excellent commercial instruments available for this purpose. The percentage of dust removal for commercial air-cleaning devices should lie between 80 and 98 per cent, and the minimum removal under such conditions should be specified and guaranteed by the manufacturer.

CODE FOR AIR CLEANERS

A Code for the Testing of Air Cleaning Devices is now being developed by a Committee of the AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS and considerable research is being carried on for this work.

RATING OF AIR CLEANERS

Air washers and filters are rated as follows:

1. Capacity in cubic feet of air handled per minute.
2. Resistance in inches of water which the cleaner offers to the flow of air at its rated capacity.
3. Percentage of dust removal at its rated capacity.
4. Percentage of entrained moisture remaining in the air after passing through the cleaner while operated at its rated capacity.
5. If considered as a humidifying agent, the humidifying and dehumidifying efficiency.

CHAPTER XXX

OZONE IN VENTILATION

Physical, Chemical and Germicidal Properties, Deodorizing Ozone Production, Proper Concentration, Industrial Uses.

OZONE is a normal constituent of pure, natural air and its quantity varies with the topography of the country, particularly with regard to the altitude, the presence of bodies of water, and certain plant life.

Ozone is produced, photo-chemically, by ultra-violet light of short wave length (120-180 μμ), while light of greater amplitude (300-330 μμ) exerts a decomposing effect. At high altitudes, where short wave radiations are more intense, ozone naturally occurs in greater quantities. It is continuously under the destructive effect of longer waves, however, but a dynamic equilibrium is finally reached between the rate of formation and the rate of decay, which shifts with the altitude. Since light of longer wave length penetrates closer to the earth than does that of shorter amplitude, the equilibrium becomes favorable to ozone directly as the altitude.

In summing up the evidence at hand it may be concluded that ozone, while mostly absent from city air, is normally present in pure country air, but in amounts that are difficult to estimate accurately. In nature the air is continuously under ionizing influences, and the enclosing of air, as in buildings, excludes these influences, in addition to destroying the original ionization of the air. Ionization is involved in chemical activity.

The process of ozonizing, in addition to supplying ozone, ordinarily absent from city air, further provides considerable ionized oxygen, producing a fresh, chemically active air, comparable with fresh, pure air of nature.

Physical Properties

Density—Observed Values; 1.657 (Otto, Direct weight method).
1.717 (Soret, by diffusion).
Calculated Value; 1.66

The foregoing values refer to air as unity. Its rate of diffusion, with respect to oxygen is 0.75.

Heat of Formation—The production of ozone is an endothermic reaction, the heat of formation being 34,000 calories per gram molecule (Jahn, Zeit. Anorg. Chem. 68, 250; 1910).

Boiling Point −112 deg. cent. (International Critical Tables, 1926).

At a temperature of 270 deg. Cent. (518 deg. fahr.), Ozone is instantly decomposed.

Odor—Strong, penetrating and characteristic. Perceptible to the sense of smell in concentrations above 0.01 p.p.m. by volume (Hill & Aeberly, *Heating and Ventilating Magazine*, December, 1921).

Olfacty (minimum perceptible concentration expressed in molecules per c.c.) 2.705×10^9 at 0 deg. cent. and 760.

Solubility—Soluble in water and dilute acids, quite soluble in carbon tetrachloride and many vegetable oils.

Material for this Chapter prepared especially for THE GUIDE by Frank E. Hartman.

Its solubility in water, like all gases, is dependent upon the temperature and partial pressure. Nernst (Festschrift, 391; 1912) gives the solubility coefficient for water, at 0 deg. cent. and 760 m.m. Hg., as 0.494; or about ten times as great as oxygen. However, high concentrations of ozone, in solution, in water, are not easily obtained in practice, due to the low concentrations at which ozone is available commercially. Of the two factors, temperature appears to have the greatest bearing, as evinced by the following tabulation wherein the experiments are listed in order of decreasing pressure, with only small variations in temperature. The experiments listed here are typical of many hundred of the kind, made by the author.

EXPERIMENT NO.	GAGE PRESSURE ABOVE AN ATMOSPHERE mm Hg	PARTIAL PRESSURE OF O_3	TEMPERATURE DEG. CENT.	SOLUTION OF O_3 IN H_2O ppm BY WEIGHT	CONCENTRATION mgs. O_3 PER LITRE OF AIR
19	300	5.83	21.5	1.7	11.0
82	240	5.75	17.5	3.0	11.5
22	300	5.72	20.5	1.5	10.8
151	150	4.87	17.7	1.98	10.7
4	500	3.19	21.5	1.0	4.7
10	500	3.19	18.9	1.7	4.7

Chemical Properties

Ozone is one of the strongest oxidizing agents known. It is capable of oxidizing all of the elements, with the exception of gold and some of the metals of the platinum group.

In the dry state its activity towards metals is not so marked, and in very low concentrations, such as used in ventilation, it may be considered as being practically inert towards the common metals.

It exerts a depolymerising action on the rubber molecule, its destructive effect being quite characteristic even at comparatively low concentrations (ca. 3 to 4 ppm). However, unless the rubber is under stress, fairly high concentrations (ca. 50 to 100 ppm), fail to effect it appreciably. The low concentrations used in ventilation have no noticeable effect on ordinary rubber goods.

Iodine is liberated from potassium iodide by ozone. Many of the low oxidation salts (ous salts) are carried to a higher degree of oxidation (ic salts) by ozone.

Generally, ozone reacts to liberate molecular oxygen, only the third atom entering into combination. This may be expressed by the equation:

$$M + O_3 = MO + O_2 \quad \text{(a)}$$

which is typical of the inorganic reactions of ozone. In many cases, however, ozone reacts as follows:

$$M + O_3 = MO_3 \quad \text{(b)}$$

This reaction is examplified in the oxidation of sulphur dioxide:

$$3SO_2 + O_3 = 3SO_3$$

Reaction (b) is more typical of the organic, than the inorganic, reactions of ozone, as illustrated by the oxidation of urea:

$$CO(NH_2)_2 + O_3 = N_2 + CO_2 + 2H_2O \quad \text{(c)}$$

In the oxidation of odoriferous substances, commonly met with in ventilation, such as skatole, indole, amine compounds, and the like,

reaction (c) may be said to hold throughout. Where an amino group is present, molecular nitrogen will be produced, in addition to the carbon dioxide and water produced from hydrocarbons.

Germicidal Properties

Ozone compared with other gaseous germicides, generally used for fumigation, rightfully holds first place, as is revealed by the following table:

Agent	Per cent necessary in moisted air to be germicidal
Ozone	0.1
Formaldehyde	1.0
Sulphur Dioxide	4.5

One-tenth per cent by weight, of ozone in air is equivalent to approximately 560 parts per million. Such a concentration of ozone could never be used in ventilating work. Rideal (Ozone, D. Van Nostrand) cites 0.05 per cent concentration as germicidal in air. Hill and Aeberly (*Heating and Ventilating Magazine*, February, 1922), report noticeable bacteriacidal effects in concentrations ranging from 300 to 450 ppm by volume. Ozone, even in respirable concentrations, is effective in inhibiting the development of fungi in cold storage; however, its action is inhibitory and not destructive.

Deodorizing

T. Graham has pointed out that odoriferous substances are susceptible to oxidation. It is further known that most odoriferous substances contain unsaturated valencies, which render them particularly susceptible to attack by ozone.

The so-called odors of animal effluvia, frequently encountered in crowded places, and where a large percentage of the air is recirculated, consists of low oxidation gases, and whilst present only in vanishingly small quantities, are highly odoriferous. These gases are completely and rapidly oxidized to odorless and innocuous products by ozone.

Hydrogen sulphide is thrown off in small quantities by man, and is frequently present in the air in relatively large quantities, as the result of many industrial operations. Ozone oxidizes hydrogen sulphide very rapidly; under some conditions to sulphuric acid and under other conditions to free sulphur and water.

Products of putrefaction, such as trimethylamine, indole, skatole, the mercaptans, etc., are readily oxidized by ozone; as are the odors arising from foods, especially during cooking. Many of the odors resulting from the combustion of organic matter are destroyed. Sulphurous gases produced by the combustion of coal are completely oxidized, whilst many of the unsaturated gases resulting from the incomplete combustion of natural gases, oil and spirit fuels, are deodorized by ozone.

Carbon monoxide is but slowly oxidized to the dioxide, the reaction being accelerated by the presence of a catalyst and also at elevated temperatures. However, the molecular concentrations of ozone must be comparable, and preferably in excess of, that of the CO, in order to obtain reaction velocities of sufficient value for practical purposes.

In garages and testing rooms the air is frequently contaminated with gasoline vapors and unsaturated gases, resulting from incomplete combustion, which cause headaches and feelings of lassitude. Ozone is valuable in oxidizing these gases and freeing the air from odor. However, CO must always be taken into consideration. It is an odorless and very insidious poison, since the victim has no warning of his condition until coma is induced. Four parts of CO per ten thousand of air is the maximum concentration which may be respired continuously without noticeable effect. (Henderson, Yandell, et al—*Journal. Ind. Hyg.* Vol. 3, 1921). Carbon monoxide frequently has been found present in quantities much greater than four parts per ten thousand in the atmosphere of garages and the like, and so far, adequate ventilation is the only remedy known. It is obvious that, chemically, ozone has nothing to offer for carbon monoxide correction, since the reaction is, at best, slow in the absence of a catalyst, and a molecular concentration of ozone comparable with a lethal concentration of CO, would produce quite as much physical distress as the carbon monoxide. Carbon monoxide is the index of good garage ventilation; this factor may be favorable and still an odoriferous condition, causing minor distress, may attain. Here ozone is of value, but it must be used with judgment, and does not permit of a curtailment of any of the ordinary CO precautions. Ozone and ionized air may possibly have some physiological effect on the haemoglobin, which may cause a shift, in selectivity, in favor of oxygen, but to date knowledge on this subject is not available.

The Production of Ozone

The air actually passed through an ozone generator should be free from water vapor, dust and gases normally foreign to the atmosphere. Rideal (Ozone, D. Van Nostrand) states that a RH of 25 per cent, at a dry bulb temperature of 20 deg. Cent., limits the yield of ozone 60 to 70 per cent of that which would be produced with dry air, other conditions being equal. The vapor content of air to be ozonized should not exceed 0.1 grains per cubic foot, for the best results.

The presence of sulphur dioxide, nitrogen dioxide, chlorine, etc., appreciably reduces the efficiency of an ozonizer. Ammonia gas, should it be admitted to the ozone generator in appreciable quantities, may cause an explosion.

The presence of dust favors the passage of sparks, which cause thermal decomposition of the ozone, and adds to the formation of oxides of nitrogen. Ozone generators are now generally supplied with an air filter.

Sparking and "creeping discharges," which frequently form at the edges of the electrodes, should be prevented by the proper design of the electrode members.

The rate of decomposition of ozone is greatly accelerated at high temperatures, therefore, ozonizers should be operated with a minimum temperature rise. At room temperatures the rate of decomposition is negligible.

Due to the catalytic effects on the decomposition of ozone, inherent in commercial ozonizers, there is a decided limiting concentration at which ozone may be produced. As a rough approximation, it may be stated

that the rate of decomposition is proportional to the concentration of ozone. Thus, the energy necessary to produce high concentrations is much greater than that required to produce the same weight of ozone in a more dilute state. The rate of air flow, to energy input, determines the concentration; therefore, air flow is a very important factor in ozonizer design. However, it must be pointed out that the yield does not increase indefinitely, with increasing air flow; and since the power required to dry the air is considerable, in relation to the power required to produce the quantities of ozone used in ventilation, it becomes necessary to strike a compromise between these two costs, in order to obtain the lowest gross cost of production.

Hill and Aeberly (*Heating and Ventilating Magazine*, December, 1921) have published graphs showing the relation between yield of ozone and air flow, while Hartman (*Ice & Refrigeration*, November and December, 1924) has given a detailed analysis of this factor, in the terms of dollars and cents.

Analysis of Ozone-Air Mixtures

Ozone, in air, is best determined quantitatively by iodimetric titration. Of the numerous methods, for the quantitative determination of ozone, that have been advanced from time to time, none combine as high an order of accuracy with simplicity of technique, as does this standard method, the technique of which is familiar to all chemists or may be found in any textbook of volumetric analysis. A few precautions, not ordinarily described in standard textbooks, should be observed when applying this method to ozone determinations (See Hartman, F. E., Analysis of Ozone-Air Mixtures, *Aerologist*, August, 1926.)

As the output of an ozonizer can be very closely controlled by the manufacturer, it is recommended that the output be checked, when desired, by an analysis of the ozonized air coming directly from the ozonizer, thus eliminating the errors inherent in fan deliveries, leakage, etc., which may be addative, and of sufficient magnitude to give quite an erroneous idea of the performance of the ozonizer.

It is frequently desirable to determine the concentration of ozone actually produced in the spaces for which the ventilation is intended. Such concentrations are generally of the order of 0.01 ppm minimum, to about 0.5 ppm maximum, and are without the range of accuracy of the standard iodimetric method. A fairly accurate, and comparatively simple, method for determination of concentrations of this order has been devised by Yant, Jones & Houghten, which is described in detail in the Transactions, A. S. H. & V. E., Vol. 29, p. 331 et seq., 1923.

Periodical checks of the actual output of the ozonizer, together with a check of the concentration established in the ventilated spaces should be fruitful of exceedingly interesting and suggestive data.

Determining Proper Concentration

The concentration of ozone in the air of ventilated spaces, should not be allowed to rise appreciably above 0.01 ppm. However, this does not mean that this is the proper concentration to introduce. The quantity of ozone necessary to maintain this concentration will depend upon what has been aptly termed "respiratory load," or cubic feet of air, per person,

per unit of time; together with a consideration of such odoriferous operations as may exist in the ventilated spaces, and the purity of the source of air supply. Thus air drawn from near the level of the city streets will require more ozone to maintain the proper concentration, than will air drawn from purer sources. This applies equally to air drawn from the vicinity of stock yards and the like.

Likewise restaurants, smoking rooms, dance halls, and theatres will require a greater quantity of ozone than will schools, offices, etc. Department stores, particularly the basements, due to odors arising from fabrics and other wares, require special consideration. There is also what may be called the "building coefficient," which includes the length of the duct system, the heights of the ceilings, and the condition of the ventilating system, whether old and dusty or new and clean, together with the rate of air change, and whether humidity control is provided or not.

In industrial ventilation, where specific contaminants are to be contended with, a knowledge of the concentration and character of the contaminating substances is essential for best results. Ozone is not a cure-all for industrial odors in general, for instance, allyl alcohol vapors, which possess an annoying odor, when subjected to action with ozone, produce the aldehyde acrolein, which is exceedingly irritating, even in very small concentrations. Here harm rather than good will be done. It is best to submit problems of this character to engineers experienced in the use of ozone for definite recommendations.

It has been recommended (Hill & Aeberly, *Heating and Ventilating Magazine*, March, 1922) that sufficient ozone capacity be provided to permit of building up comparatively high concentrations when the building is not occupied. In schools, for example, the ozone equipment should be operated at a capacity to give perhaps 0.01 ppm of ozone when the building is occupied, and after the pupils have left the building, the full capacity of the machine should be used, closing all openings, recirculating the entire amount of air, and building up a sufficient concentration to exert the maximum deodorizing effect throughout the building, the duct work and mechanical equipment.

For general ventilation, under average conditions (85 per cent ventilation), the ozonizer should be of sufficient capacity to provide a concentration of 0.05 ppm of ozone in the fan volume. For 100 per cent ventilating systems a lesser quantity can be made to suffice. A generalization cannot be made broad enough to cover the many special conditions, particularly problems of specific deodorization.

Determining Required Capacity

Having chosen the maximum required concentration of ozone, for the purpose in hand, it becomes necessary to calculate the capacity of the ozonizer. There seems to be no agreement, among makers of ozone equipment, regarding the unit of rating for ventilating ozonizers. There are three methods in common use, as follows:

Parts per Million: wherein the ozonizer is rated in parts per million (generally by volume) in some specific air volume. At first this may seem a very desirable method for rating ozonizers, as it is simply necessary to state the ppm of ozone, required for the specific CFM of air. Ozonizers so rated, have their ozone meter calibrated in ppm for the specified CFM, and should the fan volume be varied, the meter is liable to become

misleading, as the original CFM may not always be considered when reading it. Consideration of the original CFM, and proportioning to any new CFM, is essential with an ozonier so rated, if accurate knowledge of the concentration employed at any other CFM is desired.

Ozone is generally applied on the basis of ppm by volume, and as there is no existing agreement concerning a standard temperature and pressure at which the ozonizer should be calibrated, this method of rating leaves the actual capacity of the unit open to question, unless the temperature and pressure employed for calibrating is stated. Since weight is unaffected by temperature and pressure, and as ozone is determined chemically, directly in the terms of weight, weight forms a better basis for the rating of ozonizers, and eliminates a number of qualifying factors, together with tedious calculations in ozonizer design.

Milligrams per Minute: Ozonizers so rated have their ozone meter calibrated directly in the terms of milligrams per minute, and leave no questions concerning the actual capacity of the unit. Errors of omission are further circumvented by forcing a consideration of all factors, when determining the concentration of ozone in the air of the ventilating system.

The expression ppm, generally means parts per million by volume at room temperature and average barometric pressure, when referred to ozone in ventilation. One litre of ozone at 25 deg. Cent. and 740 mm Hg, weighs 1.9127 grams. Taking these conditions as a basis, the weight of 1 cc. of ozone may be taken as 2 milligrams, yielding a very convenient figure for use, easily remembered, and sufficiently accurate for all practical purposes. The metric system is best employed here, for convenience of analysis and calculations of design, with final conversion into English units for purpose of application. It is on this basis that the following formulae have been derived:

Formulae for Application:

CFM = fan capacity, cubic feet per minute of air.
mpm = milligrams of ozone per minute.
ppm = parts of ozone per million parts of air, by volume, at 25 deg. cent. and 740 mm. Hg.
28,320 = cc per cubic foot.
2 = weight of 1 cc of O_3 at 25 deg. cent. and 740 mm. Hg.

Given: CFM and ppm; Find: mpm

$$\frac{\text{CFM} \times \text{ppm}}{10^6} \times 28{,}320 \times 2 = \text{mpm}$$

which reduces to:

$$\frac{\text{CFM} \times \text{ppm}}{10^3} \times 56.64 = \text{mpm} \qquad (1)$$

Given: mpm and ppm; Find: CFM

$$\frac{\text{mpm} \times 10^3}{56.64} \times \frac{1}{\text{ppm}} = \text{CFM} \qquad (2)$$

Given: mpm and CFM; Find: ppm

$$\frac{\text{mpm}}{56.64} \times \frac{10^3}{\text{CFM}} = \text{ppm} \qquad (3)$$

Ventilating Unit—The Ventilating Unit (VU) has been created by the author, for the purpose of simplifying the calculations for applying ozone to ventilating systems. It is a compound unit, taking into consideration quantity and time. It is analagous to the horsepower, wherein 33,000 lb. are lifted one foot in one minute. It represents that quantity of ozone necessary to produce a concentration of 0.1 ppm in 1,000 CFM, at 25 deg. cent. and 740 mm Hg.

1 VU = 5.7 milligram of O_3 per minute
340 milligrams of O_3 per hour

The formulae for its application are very simple:

Given CFM and ppm; Find VU

$$\frac{\text{CFM}}{100} \times \text{ppm} = \text{VU} \qquad (4)$$

which reduces to pointing off two places in the CFM and multiplying by the ppm.

Given: VU and CFM; Find: ppm

$$\frac{0.1 \times VU}{CFM} \times 1{,}000 = ppm \quad (5)$$

which reduces to pointing off three places in the CFM, one place in the VU, and dividing the former into the latter.

Given: VU and ppm; Find: CFM

$$\frac{1{,}000}{ppm \times 10} \times VU = CFM \quad (6)$$

As the VU represents a definite weight of ozone, in a definite period of time, ozonizers so rated leave no question as to their actual capacity. The decimal character of the unit admits of much facility in calculations.

WATER PURIFICATION

Ozone finds a very important application in the purification of water. Operating costs rarely exceed an energy expenditure of 500 watt-hours per thousand gallons.

Ozone successfully eliminates odors and tastes of organic origin, particularly the tastes and odors due to excessive chlorination, and the presence of chlorinated phenols and tarry substances. Organic colors are bleached, and the effluent of a properly designed ozonizer is practically sterile.

The essentials of a good water ozonizer are an adequate and constant supply of ozone, in sufficiently high concentrations to effect high solubility at normal temperatures, adequate mixing of the ozonized air and water, under conditions which produce maximum diffusion and absorption, and over a sufficient period of time to effect sterilization. The control should provide under and over voltage release, together with a release for water pressures too low to efficiently operate the mixing device.

INDUSTRIAL USES

Ozone finds a number of applications as an oxidizing agent, in industrial operations, many of which are of little interest in ventilation. However, ozone may be used to accelerate the drying of paints and varnishes, the "oxidation" of drying oils, and many other drying operations involving oxidation. Such problems are generally specific, and it is advisable to consult the manufacturers of ozone equipment concerning them.

COLD STORAGE

Ozone is of value in cold storage for the prevention of mould development, deodorizing of storage spaces, after removal of odoriferous products, to prepare for other commodities. The preservation of flavor, particularly in eggs, and the general freshening and vitalizing of the air, the advantage of which is reflected by the superior condition of products stored in "fresh" air over those stored in "dead" air.

CHAPTER XXXI

METHODS OF DRYING

Natural Drying Types of Dryers, Moisture Content, Air Circulation, Moisture Removal, Heat and Air Volume, Required Time of Drying, Dryer Construction.

DEFINITION OF TERMS

DRYING is usually understood to mean the removal of moisture (usually water) by evaporation. In its broader sense, it includes such processes as dessication, concentration, distillation, ordation, baking and calcining. In this discussion the term drying will be limited to the removal of moisture by evaporation.

The material to be dried may be in a liquid, plastic or solid form. In the case of substances containing an excessive amount of free water, the evaporating process is often preceded by the removal of a part of the water by such methods as gravitational settling, filtration, condensation, absorption by contact with dry materials, or mechanical extraction with presses or centrifuges.

NATURAL DRYING

In *natural drying*, evaporation is obtained by utilizing the sensible heat of air at ordinary temperatures (air drying), or by exposure to the radiant heat of the sun (sun drying), or by a combination of the two. For many industrial processes, natural drying is either unsatisfactory or uneconomical.

Artificial drying produces evaporation artificially by supplying heat to the material either (1) by contact with surfaces heated by combustion, steam, hot water, heated oil, electricity, or latent heat of condensation, (2) by radiation directly to the material from a heated surface, or (3) through a current of heated air, superheated steam, or other gas, such as products of combustion, passing over or through the material. Evaporation may occur either at the boiling point, in a saturated atmosphere, or at a temperature below the boiling point. In the latter case, the vapor pressure of the surrounding atmosphere must be maintained below the vapor pressure of the liquid in the material through some means of producing a circulation of air and vapor and of removing the evaporated moisture from the air. Where products of combustion can be used, a particularly high overall efficiency of the dryer is possible.

Radiant heat, transferred to the material by direct radiation from heated surfaces, is sometimes used to supplement the heat supplied by

Material for this Chapter was prepared especially for THE GUIDE by the following committee: D. R. Brewster, *chairman*; B. S. Harrison and A. E. Stacey, Jr.

air currents or gases. About one-third to one-half of the heat given off by a radiating surface passes through the air to the object which is to be dried, without materially raising the air temperature. The remaining portion of the heat from the radiator warms the air by convection and produces warm air currents which assist in the removal of the moisture. From five to fifteen times as much radiating surface is required for radiant heat as would be needed to heat the same amount of material by heated air currents, so that this method is limited to those operations where the advantages of radiant heat will offset the higher first cost of the equipment.

TYPES OF DRYERS

Film dryers are used for drying thick liquids, pastes and semi-pastes. A thin film of the material is spread over heated cylinders, usually heated by steam and the dry product is scraped off with a knife scraper into a conveyor or receptacle.

Agitator dryers of the *rotary* or *pan* type are used for drying sludges, slimes and fine powders. The material is kept in a continual state of movement or agitation by means of revolving blades or scrapers and by the rotation of the cylindrical container in the case of the rotary dryers. Heat is transferred to the material either directly by contact with steam jacketed casings or rotating steam pipes attached to the agitators or indirectly by passing heated air or gases through the rotary cylinder.

Agitator dryers of the *hearth* or *trough* types as well as the rotary type are used for drying organic waste products. These granular materials are also dried in *vertical* dryers, in which the material drops more or less vertically through currents of heated air either with or without contact with heated surfaces.

Cylinder dryers are used in drying flexible material in long lengths such as textile fabrics of all kinds, paper and fiber board products. Heat is transferred to the material by direct contact with a series of steam heated cylinders.

Vacuum dryers are adapted to liquids, pastes or finely divided granular materials of a delicate nature such as valuable food products which must be dried rapidly at low temperatures in order to preserve flavors and other properties which might be impaired if the drying were done at the higher temperatures necessary with atmospheric pressures. Heat must be supplied to the material either by conduction in contact with a heater container, which is the usual method, or by direct radiation, either from the heated walls or shelves of the container or from the radiating surfaces within the container. The vapor is removed by means of condensers in the vacuum line. Some materials containing only 2 to 3 per cent moisture are first heated before being put in a vacuum chamber. When the vacuum is pulled, the heat vaporizes the moisture and becomes latent, thus cooling the material at the same time.

Spray dryers are used for the drying of thick liquids including any product in solution, suspension, or emulsion. The liquid is first condensed to from 35 to 50 per cent solid content and is then atomized in the form of a fine spray which is distributed in a current of air, heated to a considerably higher temperature than would be used for the same material in a contact dryer. The moisture in the material is vaporized

almost instantly, leaving a dry flour-like powder which falls to the bottom of the dryer. The spraying is done by atomizing nozzles worked either by the pressure of the liquid or by compressed air, or by whirling plates or rotating beaters.

Tumbler dryers are used for drying camp clothing and similar articles. The material is revolved in an open cylinder covered with wire or perforated sheet metal through which a current of heated air is blown.

Air current dryers, of either the *continuous* or *charge* type, are used for drying material in masses of considerable thickness or size and having a close or open texture and a cellular, granular or fibrous structure. The material is placed on trays, trucks or moving conveyors inside of a room-like enclosure and heated by contact with warm air currents which also serve to carry away the evaporated moisture. Drying of this sort is sometimes called "air-processing." The air is warmed, either by direct mixture with furnace gases or by contact with surfaces heated either by direct flame, flue gases, steam or hot water. The source of heat may be either "direct"—located within the dryer, usually in the form of wall coils, floor coils, or distributed coils—or "indirect," the air being heated by radiators outside the dryer and circulated through the dryer by fans and distributing ducts.

Continuous and Intermittent Dryers

Dryers are called *continuous* or *progressive* when a minor portion of the charge is removed and a like portion admitted at more or less regular intervals or in a continuous flow. Continuous dryers are used whenever there is a sufficiently steady production to keep the dryer functioning at approximately full capacity and whenever the duration of the drying period is less than 6 hours or more than 24 hours.

Liquids are adapted to continuous dryers of the film or spray type. Sludges, organic wastes and loose granular materials are dried in continous dryers of the agitator variety including hearth, rotary, pan and trough types. Flexible materials in long lengths are dried continuously on cylinder dryers, while room dryers of the tunnel type are used for bulky products placed on movable trays, trucks, or endless conveyors. For heavy materials, such as lumber, handled on trucks, the rails in the tunnel are often sloped toward the discharge end in the ratio of from 1 in 60 to 1 in 100 to obtain the benefit of gravity in moving the material.

Continous tunnel dryers do not lend themselves to exact control of drying conditions for the following reasons: variation in the amount of evaporation from the material, irregularity of charging and discharging and the opening and closing of doors permitting heat to escape and outside air to enter thus effecting the temperatures and humidities in the dryer.

Intermittent or *charge* dryers are charged in one operation and discharged again after the drying is completed. Vacuum dryers and room dryers of the compartment type are the principal kind of dryers operated in this manner. *Compartment* dryers consist of an enclosure in which the material is arranged on trays or trucks or in piles in such a way that currents of heated air pass over the surfaces. The material is usually stationary but is sometimes shifted in position or kept in motion for greater uniformity and speed of drying.

MOISTURE CONTENT CALCULATIONS

Moisture content is usually expressed as a percentage of the original combined weight of the material and its contained water. Thus, if the moisture content were 20 per cent, the dry material would weigh 80 per cent of the total weight. In drying some types of material, notably lumber, it is customary to use the "bone-dry" or water-free weight of the material as the divisor (100 per cent), the weight of the water being calculated as a percentage of this dry weight.

Regain is practically always expressed by the latter method, as a percentage of the water-free weight of the material.

Moisture Transfusion and Gradient

The rapidity with which evaporation can be carried on at the surface of a material depends upon the *rate of transfusion* or movement of water from the interior to the surface. This is particularly important with thick, bulky, solid substances such as clay and lumber in which the rate of transfusion is slow and which shrink with loss of moisture. In drying material of this kind, the rate of evaporation must be retarded by the use of high humidities in order to prevent too rapid drying and shrinkage of the surface, with consequent case-hardening rupture or distortion of the material. At the same time, internal transfusion must be stimulated by the use of as a high a temperature as the material will stand. At any given temperature, the rate of transfusion varies inversely as the thickness of the material, therefore the minimum time for drying varies approximately as the square of the thickness of the material. See *low temperature drying* for a discussion of case-hardening.

What is known as the *moisture gradient*, between the moisture content at the center of the material and the moisture content close to the surface, is determined by the rate of evaporation at the surface and the rate of transfusion from the center outward. In drying hygroscopic or colloidal materials, good drying practice ordinarily requires that this gradient be held within a narrow range in order to avoid case-hardening or damage due to rapid shrinkage of the surface of the material.

With every material having hygroscopic properties, a point of *equilibrium* is reached at any given temperature between the vapor pressure of the moisture in the air and the vapor pressure of the moisture in the material. In rapid artificial drying at high temperatures, an extremely low moisture content is often produced in the material which is below its natural *equilibrium moisture content* (E. M. C.) in ordinary air. The percentage of moisture that it re-absorbs from the air is sometimes called the *regain*. It varies with the relative humidity of the air and decreases to some extent as the temperature increases.

High Temperature Drying

In what is known as *high temperature drying*, temperatures range from 212 to 1000 deg. fahr. or more. Since these temperatures are above the boiling point, all of the water in the material will vaporize quickly at atmospheric pressures and the humidity of the air becomes of minor importance.

Within the critical limits, many materials produce better results if dried quickly at maximum temperatures than if dried more slowly at lower temperatures. It is important to remove products of oxidation as well as explosive or inflammable gases as quickly as possible, by means of ample circulation. Agitator fans within the dryer are often used in high temperature work to create the necessary velocity for close contact without moving an excessive volume of air. In drying with temperatures above the boiling point, it makes little difference whether the superheated vehicle is gas, air or steam. Static electricity which sometimes accumulates with hot dry air and makes powders and fabrics difficult to handle, may often be controlled with a small steam spray. Many materials dried at high temperatures are soft when removed from the dryer and must be hardened in air that is warm enough and dry enough to prevent sweating and moulding.

Low Temperature Drying

Air processing at temperatures below 200 deg. fahr., involves control of both the temperature and the relative humidity of the air, as well as the velocity and uniformity of circulation. Regulation is governed so that evaporation from the surface is allowed to proceed only as fast as moisture transfuses from the interior of the material, after allowing a safe moisture gradient to be set up.

In the early stages, when the material contains a considerable amount of free water, a relative humidity of between 80 and 90 per cent is usually called for, with a comparatively low temperature in the case of materials of cellular structure which are liable to collapse if allowed to become too hot when still very moist. At these high humidities, a rapid and uniform circulation is essential to secure uniform drying and the housing of the dryer must be well insulated in order to prevent condensation on the material and on the inner surfaces of the dryer, particularly the ceiling and air ducts.

As the drying proceeds, successive changes in the moisture content and condition of the thicker and more exacting materials call for gradual increases in temperature and decreases in humidity until the final stage is reached. This is usually a somewhat lower moisture content than equilibrium under conditions of use, to allow for enough regain to balance the moisture remaining in the interior and surface to a uniform condition. For every temperature there is a certain humidity which will dry the material to a certain point and then stop. It is usually undesirable to allow the drying to proceed much beyond the equilibrium point of the material in use, as over-drying is liable to produce undesirable physical changes in the material, and such over-drying also unnecessarily prolongs the time and increases the cost of the operation.

Uncontrolled humidity is also liable to cause excessively rapid drying of the surface of the material in the early stages. This produces a condition known as "case-hardening," the material being encased in a dry layer which it is difficult for the interior moisture to work through. In this way the drying operation is retarded and may, in some cases, be entirely stopped and replaced by a baking operation. Another harmful result in materials subject to shrinkage, such as wood and clay, is that the case-hardened surface is dried and stiffened or "set" in an expanded

condition which is later apt to restrict the normal shrinkage of the interior and cause internal rupture and distortion.

Raising the temperature of air increases its capacity to hold moisture and correspondingly lowers its relative humidity and increases its drying power. The moisture holding capacity of the air at atmospheric pressure and representative temperatures is given below:

TABLE 1. APPROXIMATE AMOUNT OF MOISTURE IN SATURATED AIR (AT NORMAL ATMOSPHERIC PRESSURE OF 29.9 IN. MERCURY)

TEMPERATURE DEG. FAHR.	GRAINS MOISTURE PER CU. FT.	TEMPERATURE DEG. FAHR.	GRAINS MOISTURE PER CU. FT.
40	2.86	140	57
60	5.8	160	91
80	11.1	180	140
100	20.0	200	208
120	34.0	212	261

It is seen from the table that if saturated outdoor air on a rainy day, containing 5.8 grains of moisture per cubic foot at a temperature of 60 deg. fahr., is heated to 180 deg. fahr., its moisture holding capacity per cubic foot will be increased approximately 24 times and its relative humidity will be reduced from 100 per cent to 4 per cent. The result at 180 deg. fahr., would have been practically the same, no matter what the humidity of the outdoor air happened to be, and it is for this reason that outdoor humidities are of comparatively small importance in designing air processing equipment in which temperatures of 140 deg. or higher are to be used. In such dryers, *any* outside air is potentially very dry when heated to the temperature at which it is to be used.

For many exacting materials, the increased capacity of the air at higher temperatures must be offset, to a large extent, by the increased humidity required to prevent rapid surface drying. In order to maintain this increased humidity and counteract the effect of outside air entering the dryer, it is often necessary to *add* moisture to the air in the dryer to supplement what evaporates from the material. This is usually done with steam sprays although in some cases, evaporating pans, water sprays or atomizers are used.

Circulation of Air Currents

The velocity of circulating air currents must be fast enough to transfer to the surface of the material all of the heat required for evaporation. At the same time, it must also be sufficient to carry away the water vapor. The volume necessary for this purpose will correspond roughly to the volume needed for heat transfer. A third requirement is that the velocity should be sufficient to carry away the film or layer of nearly saturated air that is apt to hug the evaporating surface, and whose high vapor pressure retards further evaporation.

Circulation is expressed either by the rate of air flow over the material per minute or by the number of air changes in the dryer per minute or per hour. The former is the logical method as it expresses positive drying

power while the latter may be misleading, because of short-circuiting of some of the moving air without coming in contact with the material.

When air is saturated (at any temperature), the water vapor which it contains weighs 0.623 times as much as the air it has displaced. It follows, then, that the higher the relative humidity (that is, the greater the proportion of air that has been displaced by water vapor) the lighter will be the mixture of air and vapor.

Natural Draft

Circulation by convection, due to the rising tendency of heated air and the falling tendency of cooled air, is the only means of circulation in many of the older and simpler types of dryers. Dryers of this kind give best results with fairly high temperatures and low humidities and are adapted to drying material which will stand a considerable variation in temperature and humidity conditions without injury.

In natural draft dryers the moisture evaporated is usually allowed to escape through ventilators, to be replaced by fresh air. This means that a large amount of only partially saturated warm air is allowed to escape giving this type of equipment a low thermal efficiency. Where cold-water coils or sprays are used for moisture removal, a somewhat higher efficiency is obtained. Natural draft dryers are sensitive to changes in outside wind and weather and the temperature and humidity conditions within the dryer usually vary within a wide range since such variation is necessary in order to obtain enough difference in specific gravity to produce a vigorous circulation.

The direction of natural air currents is difficult to control; they often short-circuit from one part of the dryer to another, leaving portions of the material surrounded by stagnant air of low drying power. In some designs, this is partly overcome by the use of baffles and ducts for guiding the air and by the use of water sprays or steam jets placed at certain points for the double purpose of increasing the velocity of the air as well as adding to its humidity. Tunnel dryers are better adapted to a natural draft circulation than are compartment or charge type dryers. The desirability of maintaining higher temperature and lower humidities at one end of the tunnel than at the other creates a rising circulation at one end and a falling circulation at the other which produces a general endwise circulation of air through the dryer. The higher the temperature and the longer the tunnel, the greater will be the volume and velocity of air movement.

In most dryers of the tunnel type the flow of air is opposite to the flow of material, or *counter-current*. The freshly-heated air, at maximum temperature, comes in contact with material in the final stage of drying at the discharge end where high heat is needed and can be safely used. This air then works its way back through the dryer to the charging end, losing heat and picking up evaporated moisture, thus giving a graduated range of conditions suited to the different stages of drying. Such dryers are often designed to create a sidewise as well as endwise movement of the air for more uniform drying. The internal circulation is usually aided by placing ventilating chimneys at the charging end of the dryer, to draw the moist air in that direction.

Mechanical Draft

Mechanical circulation is produced either by blowers of the centrifugal type outside of the dryer, or by multiple fans of the propeller type inside the dryer, or by a combination of the two.

In some designs, the general volume movement is taken care of by an external blower and the velocity over the surface of the material is obtained from internal fans, placed to furnish a transverse circulation. In any mechanical system, it is important to secure as high a volume of recirculation in the dryer as possible, as this adds to the thermal efficiency and cuts down power cost.

Mechanical systems are best suited to rapid drying under close control of both temperature and humidity and may be designed with automatic control instruments so as to hold the temperature within a range of 2 deg. fahr., and the humidity within a range of 4 per cent relative humidity. Indirect heaters of high efficiency are usually placed in the blower ducts and humidity is controlled either by steam jets, air washers or refrigerating coils in the duct system or steam sprays in the dryer itself. In such dryers, a higher thermal efficiency may be obtained by the use of interchangers, by which the saturated air from the washers is partially heated by absorption of heat from the warm, moist air returning from the dryer.

MOISTURE REMOVAL

More or less of the moisture evaporated from the material is taken care of by loss of warm moist air, either through leakage or ventilators, and corresponding influx of outside air, either by infiltration or through special openings for the purpose. It is a mistake to attempt to obtain a practically saturated condition of the leaving air, as this is apt to slow down the speed of drying and cause undesirable condensation in the moist air ventilators or ducts returning to the blower. A saturation of from 50 to 75 per cent is usually as high as can be obtained without sacrificing speed.

ESTIMATING HEAT AND AIR VOLUME REQUIRED

It is necessary to figure 2½ lb. of steam furnished to the dryer, per pound of water to be evaporated, although under the most favorable conditions of high thermal efficiency, 2 lb. of steam is sufficient. In very slow drying of thick, bulky materials such as lumber, it may require as much as 10 lb. of steam per pound of water evaporated.

The temperature will drop approximately 8½ deg. fahr. per grain of water evaporated per cubic foot of air (measured at 70 deg. fahr.) or approximately 0.62 deg. fahr. per pound of air at any temperature. Approximate calculations may be based on air *volume*, but for exact determinations, the *weight* of the air should be used, since the weight is a fixed quantity at any temperature.

CONTROL OF THE DRYING OPERATION

The wet bulb temperature is far more important, in determining the moisture absorbing power of the air, than the dry bulb temperature.

In drying very wet materials, the material takes the temperature of the wet bulb. This is important in rapid drying with hot, dry air, as the wet bulb temperature in such a case, is the only temperature that need be kept below the critical temperature limits of the material.

The higher the temperature, other things being equal, the faster will the moisture in the material transfuse to the surface, and the faster will the drying operation proceed. Hot water passes through the material more rapidly than cold water both because of its increased vapor pressure as well as its decreased viscosity. Increasing surface evaporation by greater circulation at low temperatures does not produce faster drying unless a corresponding increase in the rate of transfusion is obtained.

Several types of automatic thermostatic control instruments are available for controlling both the temperature and humidity of the air in the dryer. For many types of dryers, hand operation of valves as determined by periodic reading of thermometers and hygrometers is all that is required for good results. In other cases, such crude control would result in serious losses of material. In some operations, time controllers are used which automatically alter the conditions according to a predetermined schedule and finally bring the drying operation to a close. With other dryers, regulation is obtained in accordance with loss in weight of samples of the material suspended on sensitized scales within the dryer, the drying being automatically terminated when the samples reach the desired degree of dryness.

Extremely sensitive materials may be dried successfully in air which is kept in a continued state of practical saturation. This can be done either if the material is warmer than the surrounding air, in which case it must be heated by conduction or radiation, or if a certain amount of condensation is taking place in the surrounding air which will permit a corresponding evaporation from the material.

Suitable facilities should be provided for sampling and testing the material, and watching the conditions within the dryer. Systematic record forms are usually desirable for recording the movement of material, the length of the drying period, the temperatures and humidities at critical points in the dryer, and other operating data. Standard schedules of drying time and drying conditions for material of different thickness and moisture content are also very useful in estimating production and regulating the operation of the dryer.

DRYER ARRANGEMENT AND CONSTRUCTION

Outside handling and storage space is usually an important consideration in dryer design. Continuous dryers have an advantage in this respect since they provide storage for a considerable proportion of the material in process, while for charge dryers enough outside space must be provided to handle at least one full charge awaiting the dryer and one full charge upon removal. The more rapid the drying operation, the more efficient must be the handling facilities, in order to hold operating costs to a minimum and keep the dryer operating at maximum capacity.

An important consideration in construction is to provide tight, well-insulated doors which can be opened and closed easily, with minimum

Table 2. Drying Time and Conditions for Representative Materials

Kind and Thickness of Material	Temperature Deg. Fahr.	Drying Time
Bedding	150–190	
Cereals	110–150	
Cocoanut	145–155	4–6 Hours
Coffee	160–180	24 "
Cores, Oil Sand, for molding ½ in. – 1 in. thick	300	30 Minutes
Black sand with Goulac Binder about 6/10 of time for oil sand cores 3 in. "	480	2½ Hours
Black sand with Goulac Binder about 6/10 of time for oil sand cores 8 in. "	480	4½ "
Black sand with Goulac Binder about 6/10 of time for oil sand cores 16 in. "	700	10 "
Feathers	150–180	
Films, Photographic	90	
Fruits and Vegetables	140	2–6 "
Furs	110	
Glue	70–90	2–4 "
Glue Size on Furniture	130	4 "
Gut	150	
Gypsum Wall Board (Start Wet)	350	60 Minutes
Gypsum Wall Board (Finish)	190	
Gypsum Blocks	350–190	8–16 Hours
Hair Goods	150–190	1 Hour
Hats, Felt	140–180	
Hops	120–180	
Hides, Thin leather	90	2–4 Hours
Ink, Printing	70–300	
Knitted Fabrics	140–180	
Leather, Thick Sole	90	4–6 "
Lumber, Green Hardwood	100–180	3–180 Days
Lumber, Green Softwood	160–220	2–14 "
Macaroni	90–110	
Matches	140–180	
Milk and other Liquid Foods (Spray Dried)	250–300	Instantaneous
Molds, Green Sand; C. I. Flasks (one Surface only exposed)		
8 in. thick	600	6 Hours
13 in. "	700	13 "
Nuts	75–140	24 "
Paper, Glued	130–300	
Paper, Treated	140–200	
Rubber	80–90	6–12 "
Sand, loose, 1 in. deep	300	10–15 Minutes
Shade Cloth	240	1–2 Hours
Soap	125	12 "
Starch	180–200	1–4 "
Stock Feed, Mixed	180–220	20–30 Minutes
Sugar	150–200	20–30 "
Tannin and other chemicals (Spray Dried)	250–300	Instantaneous
Terra Cotta (air-drying in conditioning room)	150–220	12–96 Hours
Wall Board	200–250	12–24 "

labor and loss of time. Fire resistance of doors is also important, in case of outside exposure to fire risks. Insurance rates must be considered in their relation to fire protective arrangements such as automatic sprinklers, fire doors and walls, steam jets for use in smothering fires that may start inside the dryer, etc. Ceilings of dryers should be as flat as possible and the space between the material and the walls and ceiling should be held to a minimum. A factor often overlooked is suitable provision for ventilation of the space around the dryer openings so that warm moist air which may escape from the dryer when the doors are opened may be carried away before it has a chance to condense on the ceiling or windows of the building in which the dryer is located or into which it opens. Convenient arrangements for the operator should also be provided where tests can be made, records kept, and clothes changed, in case it is necessary for the operator to work inside the dryer.

SPECIAL PROBLEMS

Practically every problem in air processing and drying presents its individual considerations which affect the over-all efficiency of the final installation. The peculiarities of the material to be dried, the allowable temperature and humidities, the most efficient means of handling the material, the speed with which the process must be effected, and the mechanical or physical limitations imposed by the plant conditions themselves are all factors which must be carefully considered in the design of air processing and drying equipment.

The selection of the type and size of dryer, the method of heat supply, the method of moisture removal, the location and layout of the equipment with reference to handling the material to best advantage, are problems which may require a different solution for each installation. Engineers who specialize in the design of drying equipment have found it best to treat each case individually and develop a design and arrangement that will most nearly meet the specific requirements on the basis of research and experience.

Drying is an extraordinarily interesting problem in engineering, and thousands of the products that are in common use every day go through some sort of drying process during their manufacture. Wood when dried becomes a workable and dependable material, the leather used in shoes must submit to the drying operation, and the manner of its drying determines its value in the finished product. Clay when dried becomes ceramic ware, flour mixed with water when dried becomes macaroni, wood pulp dried becomes paper and gelatine dried and sensitized becomes photographic film. All textiles require the drying process at some time during their manufacture so that it is easy to see why the handling of each is a special problem.

REFERENCES

The American Society of Heating and Ventilating Engineers Transactions, Vol. 22, p. 479, Commercial Drying Apparatus, L. P. Dwyer; Vol. 23, p. 231, Artificial Drying with Special Reference to the Use of Gas, G. C. Shadwell; p. 255, Drying By Evaporation, F. R. Still; p. 265, Drying in Industrial Plants, J. G. Ross; pp. 339, 511, 529, 537, 545, Food Drying; Vol. 24, p. 7, High Temperature Drying, Burt S. Harrison;

p. 25, The Temperature of Evaporation, W. H. Carrier; p. 352, Bibliograph on Food Drying and Dryers; Vol. 26, p. 551, Commercial Dehydration, J. E. Whiteley; Vol. 27, p. 251, Drying as an Air Conditioning Problem, A. W. Lissauer; JOURNAL AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS, October, 1921, p. 715, A Chronological Survey of Drying and Dryers, J. E. Bolling; Modern Drying Machinery, H. B. Crenshaw, London, 1926; The Kiln Drying of Lumber, A. Koehler and R. Thelen, New York, 1926; Drying, W. H. Carrier, *Marks' Mechanical Engineers Handbook*, 2nd Ed., New York, 1924, p. 1444; Drying, *Kent's Mechanical Engineers Handbook*, 10th Ed., New York, 1923, p. 619; Calculations for Drying Design, Grosvenor, *Trans. A. I. Chem. Eng.* 1908, p. 184; The Rate of Drying Solid Materials, J. Lewis, *Ind. Eng. Chem.*, 1921, p. 427.

CHAPTER XXXII

DUST, EXHAUST AND COLLECTING SYSTEMS

Types of Systems, Air Velocity, Size of Connections, Suction at Hoods, Resistance of Conveyor Pipes, Fan Selection, Collectors.

PNEUMATIC exhaust and collecting systems may be classified in various ways. They may be classified by the economic purpose to be accomplished by the industries served, or by the type of system used.

Classifying exhaust systems by industries served, they fall in subdivisions such as, metal working, woodworking, leather and shoe manufacturing, rubber industry, flint grinding, pottery works, pulverizing works, celluloid manufacturing, printing establishments, felt hatting and fur manufacturing, textile mills, grain and cereal industry, etc.

TYPES OF SYSTEMS

The type of exhaust system to be used is determined by the industry served, kind of material handled, and the work to be accomplished. There are two general arrangements; the central and the group systems. In the central system a single or double fan is located near the center of the shop with a piping system radiating to the various machines to be served. In the group system, which is sometimes employed where the machines to be served are widely scattered, small individual exhaust fans are located at the center of the machine groups.

The group arrangement has the advantage of flexibility.

Exhaust systems are also classified by the means employed to collect dust or other material handled. The dust or refuse may be collected and controlled by enclosing hoods, open hoods, inward air leakage or general room exhaustion.

With some classes of machinery it is not feasible to closely hood the machines and in these cases open hoods over or adjacent to the machines are provided to collect as much of dust and fumes arising as possible. In this class come such machines as rubber mills, package filling machinery, sand blast, crushers, forges, pickling tanks, melting furnaces, and the unloading points of various types of conveyors.

The open hoods should be placed as close to the source of dust or fumes as possible with due regard to the movements of the operator.

When the hood has to be placed at some distance above the machine it should be large enough to encompass an area of considerable extent as diffusion is usually quite rapid.

Consideration must also be given to the natural movement of the fumes. For those that are lighter than air the hood should be over or

Material for this Chapter originally prepared for THE GUIDE by H. M. Nichols, revised by R. E. Shaw, and W. A. Rowe.

above the machine and where a heavy vapor or dust-laden air at ordinary temperature is to be removed, horizontal or floor connections are required. If it is attempted to remove heavy dust such as lead oxides by an overhead hood the conditions may be worse than if no exhaust were used at all, owing to the rising air current carrying the dust up through the breathing zones. The principle to keep in mind in all cases is to take advantage of the natural tendency of the material to move upward or downward.

In another class of operation the main object is to prevent the escape of dust into the surrounding atmosphere, the removal of some dust from the machine or enclosure being merely incidental. The dust creating apparatus is enclosed within a housing which is made as tight as practicable, and sufficient suction is applied to the enclosure to maintain an inward air leakage, thus preventing escape of the dust. While the exhaust system is only required to handle the air which leaks in through the crevices and openings in the enclosure, yet in many installations leakages are very high and great care is required to obtain satisfactory results with a system of this kind. The inward leakage principle is utilized for controlling dust in the operating of tumbling barrels, grinding, screening, elevating and similar processes.

Certain dust and fume producing operations are best carried on by isolating the process in a separate compartment or room and then applying general ventilation to this space. The compartment or room in which the work is performed should be as small as is consistent with convenience in handling the work. The ventilating system should be designed so that a strong current of clean air is drawn across the operator, and away from him toward the work, where the dust is picked up and carried from the room.

IMPORTANT REQUIREMENTS OF AN EFFICIENT EXHAUST AND COLLECTING SYSTEM

It is impracticable to enumerate all of the requirements for an efficient exhaust and collecting system, however, among the more important are the following:

1. Fans, collectors, hoods, and ducts should be of adequate size.
2. Air volume and velocities should be adequate for the work to be accomplished.
3. The exhaust hoods should not interfere with the operation of the machine or access to its working parts.
4. The system should not increase the fire hazard.
5. The system should not increase the dust explosion hazard.
6. Where power is expensive, it should do the required work with a minimum power consumption.
7. In cold climates, it should not remove any more air than necessary from the building.
8. Where power is comparatively cheap, first cost should be low, even if the power required to operate is slightly higher.

The first step in designing systems employing hoods to trap the material is to determine the number and size of the connections for each individual machine. At this point the designer's past experience is of great value, as, while it is possible to set certain general standards, yet in actual practice the sizes are considerably affected by the local conditions which the

layout man finds in the field, and he bases the pipe sizes and hoods on his judgment, being guided by his experience and the general practice.

The size of hoods and connections are determined by the size and type of machines or apparatus to be handled by the exhaust system, by the kind of material worked, by the duty of the machines and other local conditions. It is impracticable to lay down any general rules for determining size connections for the various types of machines and Tables 1 to 3, giving sizes as used in some of the common industries are only intended to serve as a general guide. Under certain favorable conditions smaller connections may be supplied.

Open bottom exhaust hoods of the canopy type, where it is impractical to enclose completely the point of origin of the dust or fumes, should extend over the machine or operation at least 12 in. in every direction if the hood is not elevated more than 2 ft. For each additional 2 ft. of elevation, the size of the hood should be increased 12 in. in all directions.

It is desirable to make the area of the connecting pipe not less than $\frac{1}{15}$ of the total hood area.

In systems employing inward air leakages the area of connections must be proportional to total leakage area in the enclosing housing.

Tumbling barrels have connections ranging from 4 to 8 in., bucket conveyors 6 to 12 in., and screening machines 6 to 10 in.

In general room exhaust large connections should be provided so that the air may be handled at low velocity and with a minimum power consumption.

After having determined on the proportions of the exhaust system as regards hoods and connections it is then necessary to choose the air velocity or suction at the hood connections, suction at the hood connections being a measure of the air velocity at that point.

AIR VELOCITY

The air velocity required is dependent upon the specific gravity of the material, the fineness of the particles, and their physical characteristics. Certain materials such as grease wools, silk waste, salt, and other hydroscopic substances are difficult to handle due to the tendency to deposit in the conveyor pipes.

While the velocity in the system should be sufficiently high to insure the removal of the material it should be kept as low as practicable since any higher velocity requires the use of unnecessary power. With a fixed system or orifice the power increases as the cube of the increase in velocity, or for the same quantity of air and material handled, inversely as the fifth power of the diameter of round ducts.

Velocities commonly employed are: 2500 to 3000 ft. per minute for light dusts, cotton, shavings and sawdust from dry wood, and similar substances. Heavy dusts, wool, shavings and sawdust from wet wood, rags, waste paper and similar materials 3000 to 4000 ft. per minute. Lead dust, hog waste, pulp chips, etc., 4000 to 6000 ft. per minute.

In choosing the pipe sizes consideration must be given to the way and manner in which the machines will be operated, as in case a considerable number of machines, all discharging into one main, should be shut off

at the same time, the velocity in the main might easily be lowered to the point where it would not be sufficient to carry the material from the machines still in operation, and thus result in clogging the pipes. Accordingly, it is sometimes desirable to use velocities higher than the minimum to allow a factor of safety to cover this contingency.

TABLE 1. SIZE OF CONNECTIONS FOR WOOD-WORKING MACHINERY

TYPE OF MACHINE	DIAMETER OF CONNECTIONS IN INCHES
Circular Saws, 12-in. diam.	4
Circular Saws, 12-24-in. diam.	5
Circular Saws, 24-40-in. diam.	6
Band Saws, Blade under 2 in. wide	4
Band Saws, Blade 2-3 in. wide	5
Band Saws, Blade 3-4 in. wide	6
Band Saws, Blade 4-5 in. wide	7
Band Saws, Blade 5-6 in. wide	8
Small Mortisers	6
Single End Tenoners	6
Double End Tenoners	7
Double End, Double Head Tenoners	10
Planers, Matchers, Moulders, Stickers, Jointers, etc.—	
With Knives, 6-10 in.	5–6
With Knives, 10-20 in.	6–8
With Knives, 20-30 in.	6–10
Shapers, Light Work	4–5
Shapers, Heavy Work	8
Belt Sander, Belt less than 6 in. wide	5
Belt Sander, Belt 6-10 in. wide	6
Belt Sander, Belt 10-14 in. wide	7
Drum Sander, 24 in.	5
Drum Sander, 30 in.	6
Drum Sander, 36 in.	7
Drum Sander, 48 in.	8
Drum Sander, over 48 in.	10
Disc Sander, 24 in. diam.	5
Disc Sander, 26-36 in. diam.	6
Disc Sander, 36-48 in. diam.	7
Arm Sander	4

In some states codes have been issued specifying suctions to be maintained for the more common dusts.

A suction standard should always be considered in conjunction with the shape of hood, and size connection, as these factors together determine the volume of air exhausted and its velocity which in turn are a measure of the effectiveness of the exhaust system.

The cubic feet of air of standard density taken into the system at each connection is given by the formula:

$$Q = 4000\, A\, f \sqrt{i}$$

where

Q = cubic feet of air per minute.
A = area of connection in square feet.
f = orifice or restriction coefficient.
i = static suction measured in inches of water.

TABLE 2. SIZE OF CONNECTIONS FOR GRINDING AND BUFFING WHEELS

DIAMETER OF WHEELS	MAX. GRINDING SURFACE SQ. IN.	MIN. DIAM. OF BRANCH PIPES IN INCHES
Grinding—		
6 in. or less, not over 1 in. thick	19	3
7 in. to 9 in., inclusive, not over 1½ in. thick	43	3½
10 in. to 16 in., " " " 2 in. "	101	4
17 in. to 19 in., " " " 3 in. "	180	4½
20 in. to 24 in., " " " 4 in. "	302	5
25 in. to 30 in., " " " 5 in. "	472	6
Buffing—		
6 in. or less, not over 1 in. thick	19	3½
7 in. to 12 in., inclusive, not over 1½ in. thick	57	4
13 in. to 16 in., " " " 2 in. "	101	4½
17 in. to 20 in., " " " 3 in. "	189	5
21 in. to 27 in., " " " 4 in. "	338	6
27 in. to 33 in., " " " 5 in. "	518	7

TABLE 3. SUCTIONS REQUIRED AT HOODS FOR CONNECTIONS OF USUAL PROPORTIONS

WORK	STATIC SUCTION IN IN. OF WATER
Exhausting from grinding and buffing wheels	1–2
Exhausting from tumbling barrels	1–2
Exhausting from wood-working machinery—light duty	1–2
Exhausting from wood-working machinery—heavy duty	2–4
Shoe machinery exhaust	2–3
Exhausting from rubber manufacturing processes	1–2
Flint grinding exhaust	1–2
Exhausting from pottery processes	1–2
Lead dust and fume exhaust	1–4
Fur and felt machinery exhaust	2–3
Exhausting from textile machinery	1–3
Exhausting from elevating and crushing machinery	1–2
Conveying bulky and heavy materials	3–5

The orifice coefficient f is dependent upon the shape and construction of the hood and will range from 60 to 90 per cent. An average value is 70 per cent.

Knowing the suction at each hood and the diameter of each connection, the volume of air passing up each branch can be taken from the accompanying Table 4. The sum of all these volumes gives the total volume to be handled by the exhaust fan.

Common practice is to provide a main suction pipe having an area 20 to 25 per cent in excess of the sum of the areas of the branches entering it between the point in question and the dead end of the main. Similarly the discharge pipe leading from the fan outlet to collector is frequently made the same diameter as the large end of the main suction pipe. The reason for this increase in size is that a considerable power saving results from the lower air velocity. However, there is no technical reason why mains should be a certain percentage greater area than the

sum of the connections, and still lower power consumption can be obtained by using larger branches and mains of equal area. While the rule of thumb method of determining size of mains works very well in many cases, yet it is always desirable to figure the mains and branches of the proper size to give the velocity which has been found best suited to the work to be done.

In certain special cases where explosive or poisonous dusts such as aluminum buffings, grain dust, powdered sugar, or lead dust are handled, increasing the size of the mains unduly would introduce a serious hazard.

TABLE 4. CUBIC FEET OF AIR HANDLED PER MINUTE THROUGH AVERAGE COLLECTING HOODS

Based on Coefficient of Orifice of 0.71 with 10 Per Cent Added for Leakage

DIAMETER OF CONNECTION PIPE IN.	MAINTAINED SUCTION—IN. WATER GAGE						
	1	1½	2	2½	3	4	5
1½	38	47	54	61	67	76	86
2	68	84	97	108	118	136	153
2½	107	131	161	168	185	214	238
3	153	188	217	243	266	306	343
3½	209	256	296	330	362	418	466
4	273	334	386	431	473	546	609
4½	345	423	488	546	598	690	775
5	427	523	605	676	741	854	955
6	614	751	867	970	1062	1228	1373
7	835	1023	1181	1322	1448	1670	1870
8	1092	1337	1546	1727	1892	2184	2440
9	1381	1694	1953	2184	2387	2762	3091
10	1705	2090	2409	2695	2959	3410	3806

The maintained resistance of the exhaust system is composed of three factors: (1) loss through the hoods; (2) collector drop; and (3) friction drop in the pipes.

Collector drop in inches of water is given roughly by the following formula: but where possible the resistance of the particular collector to be used should be ascertained from the manufacturer as these resistances differ quite widely.

$$\text{Drop} = C\left(\frac{V}{4000}\right)^2$$

where

C = a constant which depends upon the type of collector and is found to range from 0.25 to 0.75.

V = velocity in feet per minute of air entering the collector.

Friction drop in the pipes must be computed for each section where there is a change in area or in velocity. Find the velocities in each section of pipe starting with the branch furtherest from the fan. The friction drop for these sections can be determined by reference to Table 5. Total friction loss in the piping system is the friction drop in furthest branch plus the drop in the various sections of the main, plus the drop in the discharge pipe.

TABLE 5. FRICTIONAL RESISTANCE OF STRAIGHT CONVEYOR PIPE

To Flow of Air Per 100 Feet of Pipe

VEL. OF AIR IN FT. PER MIN.	LOSS OF PRESSURE IN INCHES FOR GIVEN DIAMETER PIPE						
	4"	5"	6"	7"	8"	10"	12"
2000	1.92	1.53	1.28	1.09	0.962	0.770	0.640
2200	2.32	1.85	1.55	1.32	1.16	0.932	0.778
2400	2.77	2.22	1.84	1.58	1.39	1.01	0.924
2600	3.26	2.60	2.17	1.86	1.63	1.30	1.08
2800	3.76	3.01	2.52	2.15	1.89	1.51	1.26
3000	4.33	3.46	2.88	2.47	2.08	1.73	1.44
3200	4.93	3.94	3.28	2.82	2.47	1.97	1.64
3400	5.56	4.45	3.71	3.18	2.78	2.22	1.85
3600	6.23	4.98	4.15	3.56	3.12	2.49	2.08
3800	6.95	5.55	4.62	3.97	3.48	2.78	2.32
4000	7.69	6.15	5.13	4.40	3.85	3.08	2.57
4200	8.48	6.78	5.65	4.85	4.25	3.49	2.83
4400	9.26	7.41	6.18	5.30	4.63	3.71	3.09
4800	11.05	8.85	7.38	6.32	5.55	4.43	3.69
5200	13.00	10.50	8.66	7.44	6.50	5.21	4.34
5600	15.25	12.05	10.05	8.61	7.55	6.03	5.05
6000	17.30	13.85	11.52	9.89	8.66	6.92	5.76
	14"	16"	18"	20"	22"	24"	30"
2000	0.550	0.482	0.428	0.385	0.350	0.320	0.257
2200	0.655	0.582	0.578	0.465	0.423	0.388	0.310
2400	0.790	0.693	0.617	0.553	0.504	0.462	0.369
2600	0.930	0.810	0.722	0.650	0.590	0.542	0.434
2800	1.07	0.932	0.838	0.754	0.685	0.628	0.503
3000	1.24	1.08	0.961	0.865	0.788	0.722	0.577
3200	1.41	1.23	1.09	0.985	0.895	0.820	0.657
3400	1.59	1.43	1.24	1.11	1.01	0.925	0.742
3600	1.78	1.56	1.38	1.25	1.13	1.04	0.832
3800	1.99	1.74	1.54	1.39	1.26	1.16	0.926
4000	2.20	1.92	1.71	1.54	1.40	1.28	1.03
4200	2.43	2.12	1.88	1.70	1.54	1.42	1.13
4400	2.66	2.33	2.06	1.85	1.68	1.54	1.24
4800	3.17	2.77	2.46	2.22	2.02	1.85	1.48
5200	3.72	3.25	2.89	2.61	2.36	2.16	1.75
5600	4.32	3.78	3.35	3.02	2.74	2.52	2.01
6000	4.95	4.33	3.85	3.46	3.14	2.89	2.31

FRICTIONAL RESISTANCE OF ELBOWS

Elbows having a throat radius equal to the pipe diameter set up a resistance equivalent to a section of straight pipe approximately 10 diameters long. With a throat radius of 1½ times the diameter the resistance is about the same as seven diameters of straight pipe.

SELECTING THE FAN

Having determined the volume of air and static head required, the size of exhaust fan, speed and horsepower can be found by reference to the manufacturers' performance tables or charts covering the type of exhaust fan selected.

The usual types of ventilating fans are unsuitable for exhaust systems which are required to handle materials such as shavings, sawdust, emery dust, etc. Higher pressures are required than in ventilating work and in addition housings and blast wheel must be so constructed that the materials handled do not deposit in same. While the fans used in different

exhaust systems are more or less of the same general type, modifications are frequently necessary to fit them for handling such materials as long shavings, strips of paper, cotton, pulverized coal, etc.

Where considerable quantities of explosive dust or inflammable materials pass through the exhaust fan, the blast wheel should be constructed of brass composition, copper or other soft metal and in all cases ample clearance should be provided between blast wheels and housings.

Where stringy or fibrous material is to be handled through the fan be sure to employ a fan wheel especially designed for that purpose.

COLLECTORS

The most common method of separating the dust and other materials from the air is to pass the mixture through a centrifugal or "cyclone" collector. In this type of collector the mixture of the air and material is introduced on a tangent, near the cylindrical top of the collector, and the whirling motion sets up a centrifugal action causing the comparatively heavy materials suspended in the air to be thrown against the side of the separator, from which position it spirals down to the tail piece, while the air escapes through the stack at the center of the collector.

For most systems, the inlet size of the collector may be the same as the diameter in inches of the main pipe leading to it. The larger the collector within certain limits the better will be the separation, and the less will be the back pressure on the fan and power consumed.

Special construction is sometimes required for fine dust, also some blow-pipe manufacturers use a special type of collector for furnace feed, the object being to deliver the material to furnaces as uniformly as possible.

When more than one fan delivers into a single collector a back pressure valve is required to prevent one fan blowing back through the other in case the second fan should stop for any reason.

In most plants, where wood refuse is used for fuel, it is delivered by gravity directly from the collector to the furnace. The discharge pipe leading from the bottom of the collector is divided and the junction furnished with a switch or valve so arranged that when the material comes too fast for the fires it can be diverted into a reserve bin.

The furnace feeder should be hinged where it is attached to the lower end of the discharge pipe, in order that it may be disconnected from the furnace when the fan is shut down. Also great care must be taken to provide an absolutely tight switch. Otherwise, when discharging refuse to the storage bin, fine sawdust will sift through this valve and settle in the furnace feed pipe, and, in case the fireman has neglected to disconnect the feeder from the furnace, the flame may flash back, following this train of fine sawdust, into the collector.

Other forms of collectors or separators, are: settling chambers, cloth screen and bag collectors, bag houses, air washers and electric precipitators.

DESIGN OF HOODS

The mechanical design as regards shape and construction of the hoods is extremely important. Probably more systems fail from improper hood construction than from any other one cause.

If the material to be moved is already in motion, as are the chips thrown off from woodworking machines, the hoods should be arranged in the path of the particles so that the velocity of the particles assists the air in carrying the material to the throat of the hood.

Hoods should be arranged to draw dust and fumes away from the face of the operator. They should be placed as close as possible to the source of dust or waste material and wherever practical, the hoods should entirely enclose the dust producing operation.

Hoods are usually constructed of galvanized sheet iron or other equally substantial and durable material. The material should be heavy enough to stand the abrasive action of the dust and refuse. The hoods should be of sufficient mechanical strength to keep their shape and should be well braced and substantially supported. Galvanized iron used should never be lighter than No. 22 gage.

If acid or corrosive fumes are present heavy material painted with acid resisting paint should be used, or the hoods may be made of non-corrosive material.

The exposed edges of all sheet metal hoods should be bound with wire or band iron, not only to give the necessary stiffness, but also to prevent the operator from being cut by the raw edges of the sheets.

CONVEYOR PIPES

The conveyor pipes leading from the hoods to the fan and thence to the collector are commonly made of galvanized iron, the gage of which varies from No. 24 to 14, depending upon the diameter. The piping should be free from dents, fins and projections of all kinds on which refuse material might catch.

All permanent circular joints should be lap-jointed, riveted and soldered, and all longitudinal joints either grooved and locked or riveted and soldered. Circular laps should be in the direction of the flow, and piping installed out-of-doors should have the longitudinal laps at the bottom. Every change in pipe size should be made on a taper not by an abrupt change.

All pipes passing through roofs should be equipped with collars so arranged as to prevent water leaking into the building.

The main trunks and branch pipes should be as short and straight as possible, strongly supported, and have the dead ends capped to permit inspection and cleaning. All branch pipes should join the main at an acute angle, the junction being at the side or top and never at the bottom of the main. Branch pipes should not join the main pipes at points such that the material from one branch tends to enter the branch on opposite side of main.

Cleanout openings having suitable covers should be so placed in the main and branch pipes that every part of the system can be easily reached in case the system clogs. Either a large cleanout door should be placed in the main suction pipe near the fan inlet or a detachable section of pipe, held in place by lug bands, may be provided.

Elbows should be made at least two gages heavier than straight pipe of the same diameter, the better to enable them to withstand the additional wear caused by changing the direction of flow. They should

preferably have a throat radius of at least one and one-half times the diameter of the pipe.

Every pipe should be kept open and unobstructed throughout its entire length, and no fixed screen should be placed in it, although the use of a trap at the junction of the hood and branch pipe is permissible, provided it is not allowed to fill up completely.

The passing of pipes through fire-walls should be avoided wherever possible, and sweep-up connections should be so arranged that foreign material cannot be easily introduced into them.

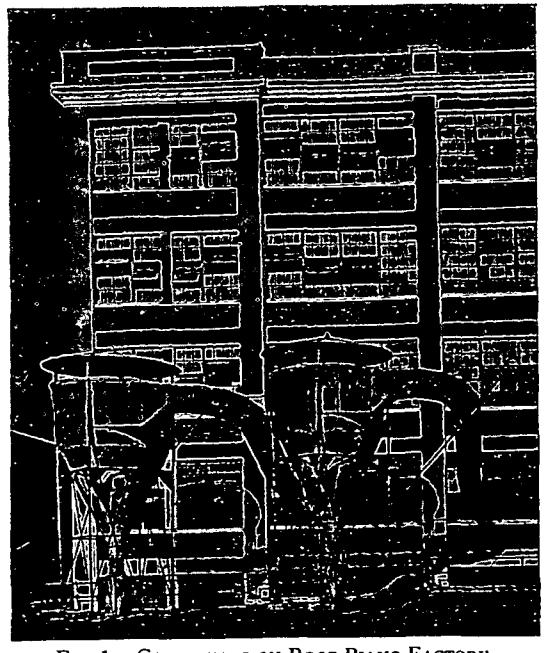


FIG. 1. COLLECTORS ON ROOF PIANO FACTORY

MAINTENANCE OF SYSTEM

Because of its simplicity the exhaust system usually receives but little attention once it is installed; however, to obtain the best results, it should be inspected at suitable intervals and necessary adjustments made.

The exhaust fan should be given proper attention the same as any other high-speed machine. It should be kept in proper alignment and tightly bolted to its foundation.

Suction hoods, which have been removed to adjust the machines, should be replaced as soon as the adjustments are completed.

Never start a machine with the blast gate closed, as the slight air leakage past the blast gate may draw material into the pipe and clog it.

Disconnect furnace feeders from the furnaces when not in operation, and do not overload the system by ill-advised additions.

CHAPTER XXXIII

NATURAL VENTILATION

Motive Forces, Proper Arrangements for Coordinating Temperature Difference and Wind Effects, Fundamental Formulae, Practical Installation Suggestions, Ventilators for Industrial, Residential and Farm Building Types.

NATURAL ventilation requires no motive power equipment and costs nothing for power to operate. Enormous areas can usually be made available for air flow, and rates of air change in excess of those usually feasible with fans may often be attained. On the other hand, natural motive forces being largely beyond human control, natural ventilation is not as amenable to regulation as a fan system.

The natural forces available for utilization in ventilation are (1) the wind, and (2) the temperature difference between the inside and outside of a building. These two forces are entirely separate and distinct, and may either cooperate or oppose each other at any given ventilating opening. If possible, therefore, openings should be arranged so that the two forces always act cooperatively, or the control should be such that only groups of openings at which cooperative action occurs will be in use.

THE WIND

The wind operates to produce regions of pressure or suction about the exterior of a building as compared with the conditions that would exist in these regions if the air were still. The action of the wind is described in a paper by W. C. Randall, Airation of Industrial Buildings, A. S. H. & V. E. JOURNAL, January, 1928. The principal effects of the wind when blowing directly against one face of a building are illustrated in Fig. 1. The maximum intensity of pressure at point C is approximately given by the equation.

$$P_w = 0.00048M^2 \qquad (1)$$

where P_w is pressure in inches of water, and M is velocity of wind in miles per hour. The mean pressure over the windward face is somewhat less, being perhaps 75 per cent of the maximum.

The maximum suction occurs at point B at roof and sides, and in magnitude is about three-quarters of the maximum pressure as given by equation (1). The distance A, measuring the extent of the suction regions on sidewalls and roof, caused by the leap, or splash, of the wind from the windward face, seems to be determined by the height and width of the windward face, and is independent of the wind velocity. The intensity of the suction diminishes from the maximum at B to zero at the point where the stream lines again flow parallel to the surfaces of the building.

Maximum effect of the wind in producing ventilation can be obtained by providing openings in the windward face for ingress of air and in the

Material for this Chapter was prepared especially for THE GUIDE by the following committee: Prof. J. E. Emswiler, *chairman:* Prof. J. P. Calderwood, Prof. F. L. Fairbanks and W. C. Randall.

leeward face, or in sidewalls and roof near the leeward face, for egress of air, in which case the air moves through the building in the same general direction as the wind; or, with no openings in the windward face, but with openings provided in the suction regions in sidewalls and roof near the windward face for egress of air, and openings in the leeward end, or in sidewalls near the leeward end for ingress of air, in which case the air movement within the building is in a direction opposite to that of the wind. A knowledge of these facts and their application will often result in a better layout of operations and processes, and even in a more favorable orientation of a building with respect to the prevailing direction of the wind, so that heat and objectionable fumes may be removed more advantageously from an industrial building.

Where the wind comes at an angle to the building, the same general rules apply. The mean pressure of the wind on the oblique faces may be considered as being approximately equivalent to the normal component of the wind, except that when the wind's direction is within 15 or 20 deg. of parallelism, the splash from the corner begins to appear, and there will then be suction near the windward corner.

TEMPERATURE DIFFERENCE

Temperature difference inside and outside a building tends to produce flow as in a chimney. The total head or force arising from this cause is given approximately by equation (2).

$$p_t = 0.000028mD \qquad (2)$$

where p_t is the total force or head in inches of water; m is the vertical distance between inlet openings below and outlet openings above; and D is the temperature difference.

The total force or head is consumed in forcing the air in at inlet openings, through the building, and out at the outlet openings. The force required to move the air through the building is usually negligible, so that the total head may be considered as being consumed at inlet and outlet openings. The part of the total head consumed in forcing the air to flow through the lower or inlet opening will be manifested as an excess of outside pressure over inside pressure at that level; while at the upper or outlet opening, the part of the total head consumed in forcing the air out will be manifested as a pressure inside, greater than outside. Thus the lower part of the building inside, will be in a state of partial vacuum with respect to the outside, while the upper part will be in a state of pressure. At some point between the levels of the two openings, the pressure state is neutral, and no flow will take place through an opening at that level. This level is called the *neutral zone*. For a discussion of the neutral zone, and effect of temperature difference in general, see paper by J. E. Emswiler, The Neutral Zone in Ventilation, TRANS. A. S. H. & V. E., Vol. 32, 1926.

RELATION BETWEEN HEAD AND FLOW

The relation between head or pressure difference on the two sides of an opening, and the velocity that will be created thereby, is given approximately by equation (3).

$$V = 4000\sqrt{p} \qquad (3)$$

where V = velocity in feet per minute through an opening, and p is the pressure difference, in inches of water, existing at that opening from any causes or combination of causes.

With V known, the flow, Q, at the opening can then be easily computed by the familiar relation.

$$Q = AVC \qquad (4)$$

where Q is the flow in C. F. M.; A is the area in square feet, and C is a coefficient.

For openings such as result from swinging or sliding windows and doors, where the aperture is essentially an orifice, the value of C will be about 0.60.

It would be comparatively easy to calculate flow through an opening, if the pressure difference could be determined. However, so many factors participate in the general action that it is very difficult to evaluate a pressure difference arising from a given wind velocity and temperature. The difficulty is further augmented by the fact that the pressure difference is likely to have a different value for every different opening or group of openings of a building.

Although it is almost out of the question to attempt to predetermine accurately the pressure difference from fundamental data of wind velocity, wind direction, temperature difference, building dimensions and disposition of openings, in most cases merely a general knowledge of how the forces of wind and temperature difference act, what their maximum magnitudes are, and how they are disposed in and about a building, will be helpful in planning ventilation. On this basis, the following simple rules are suggested:

1. In an industrial building where furnaces, that give off heat and fumes, are to be installed, it is better to locate them in the end of the building exposed to the prevailing wind. The strong suction effect of the wind at the roof near the windward end will then cooperate with temperature difference, to provide for the most active and satisfactory removal of the heat and gas laden air.

2. In case it is impossible to locate furnaces in the windward end, that part of the building in which they are to be located should be built higher than the rest, so that the wind, in splashing therefrom will create a suction. The additional height also increases the effect of temperature difference to cooperate with the wind.

3. In the use of monitors, windows on the windward side should usually be kept closed, since, if they are open, the inflow tendency of the wind, counteracts the outflow tendency of temperature difference. Openings on the leeward side of the monitor result in cooperation of wind and temperature difference.

4. In order that the force of temperature difference may operate to maximum advantage, the vertical distance between inlet and outlet openings should be as great as possible. Openings in the vicinity of the neutral zone are less effective for ventilation.

5. In order that temperature difference may produce a motive force, there must be vertical distance between openings. That is, if there are a number of openings available in a building, but all are at the same level, there will be no motive head produced by temperature difference, no matter how great that difference might be.

6. In the design of window ventilated buildings, where the direction of the wind is quite constant and dependable, the orientation of the building together with amount and grouping of ventilation opening can be readily arranged to take full advantage of the force of the wind. On the other hand, where the direction of the wind is quite variable, it may be stated as a general principle that windows should be arranged in sidewalls and monitors so that there will be approximately equal area on all sides.

Thus, no matter what the wind's direction, there will always be some openings directly exposed to the pressure force of the wind, and others to a suction force, and effective movement through the building assured.

VENTILATING OPENINGS

The openings employed in natural ventilation are:

A. Windows, representing apertures in walls or roof.
B. Roof ventilators of the unit type consisting of some kind of special construction designed to develop a localized suction from the wind, at the exterior of the opening.
C. Roof ventilators of the continuous type, giving openings throughout the length of building, having no special features to utilize the force of the wind.
D. Stacks causing flow by *gravity* (temperature difference) action.

Windows have the advantage of transmitting light, as well as providing ventilating area when open. Their movable parts are arranged to open in various ways; they may open by sliding as in the ordinary double-hung, wood window; by tilting on horizontal pivots at or near the center; or by swinging on pivots at top or bottom. Whatever the form and type of window used the thing of essential importance in ventilation is the amount of clear area that can be made available. The motive head to produce flow through windows is almost entirely dependent upon the distribution of those motive forces in and about a building, as discussed under wind and temperature difference. A pivoted window, projecting out from the plane of the wall is bound to impose some obstructive influence upon such air currents as exist in that particular vicinity, and may result in the production of some localized pressure or suction that will influence flow there, and to that degree, one type of window might give more or less active ventilation than another. But, speaking generally, the motive head causing flow through a window is determined by the forces of wind and temperature difference existing there, and not by the kind of window, except in so far as the kind of window establishes the area of opening.

Windows may be arranged for individual operation, or they may be grouped in long runs, as in factory buildings. Those used in office buildings may have deflecting devices at the sills for avoiding direct draft upon occupants, or a bottom pivoted ventilator, arranged to swing in at the top, may serve the same purpose.

ROOF VENTILATORS OF THE UNIT TYPE

A roof ventilator of the unit type consists of a structure built up around a roof opening in such a way as to cause the wind to *create* a suction in the vicinity of the opening, and so induce an outflow. Roof ventilators also have the advantage of whatever temperature difference prevails. Since they are intended for installations on roofs of buildings, and function as outflow openings only, they constitute but a part of a ventilating system, and some attention must be given to openings available for inflow. It is evident that such ventilators could not function even in the strongest wind, and with the maximum temperature difference, without inlet openings. Often such ventilators must depend upon infiltration only for inflow. Inlet openings of about twice the area of ventilators

should be provided. Dampers should be installed in ventilators, with adequate and accessible operating mechanism.

In considering roof ventilators, the general action of the wind upon the building, as described in the earlier part of this chapter, should be kept in mind.

A ventilator located within the region indicated by *A* in Fig. 1, will not contribute any inductive effect because in this region there is little or no wind. The ventilator opening will function, but will function in the same way as would a window in that locality, because of the resultant effect

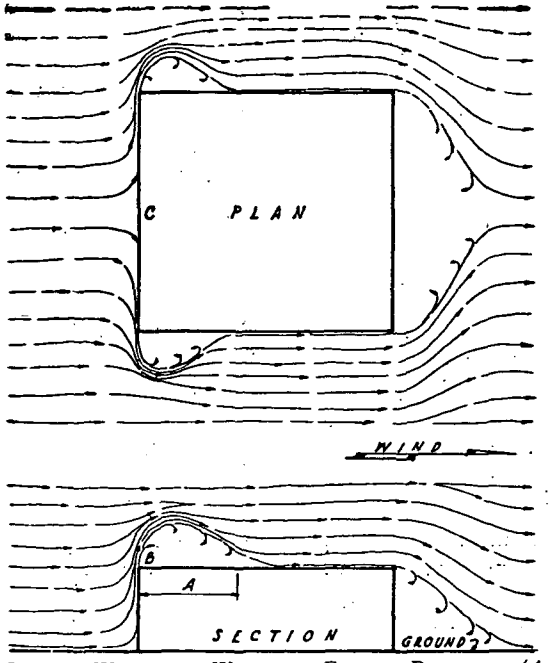


FIG. 1. THE JUMP OF WIND FROM WINDWARD FACE OF BUILDING. (*A*—LENGTH OF SUCTION AREA; *B*—POINT OF MAXIMUM INTENSITY OF SUCTION; *C*—POINT OF MAXIMUM PRESSURE)

of the suction produced by the wind acting upon the building, and by whatever temperature differences prevail.

Roof ventilators have the advantage in that the opening is effective if wind strikes the ventilator at all, no matter what the direction. On the other hand, if ventilators do not stand in the path of the wind, and depend only upon the same forces for producing flow as do windows or any other plain opening, they are at a disadvantage because of the greater resistance of their more complex passages.

While ventilators may be divided into certain classes or groups and the average efficiency of one class will be higher or lower than the average efficiency of another class, this does not in any way determine the

capacity of individual ventilators, as ventilators of the same class and, which from a casual observation appear to be the same, will have entirely different characteristics, due to the fact that some of the fundamentals have been overlooked or changed in one or the other.

The principles which should be followed are:

A—Stationary Ventilators.

1. A head sufficiently large to produce a large low-pressure area on the side opposite the wind, and to give an area of outlet for the air leaving the head large enough to obviate undue resistance to flow. At the same time the head should not be so large as to be unwieldy in handling or to be structurally weak when erected.
2. A storm band on stationary non-siphoning ventilators should be sufficiently wide and so placed as to prevent the entrance of external air into the ventilator head.
3. If the ventilator is a siphoning type, additional outlet air space must be provided in the head in order not to restrict the air passage from the exhaust pipe.

B—Rotary Ventilators.

1. A flaring outlet from a rotary ventilator will give a better exhaust than a straight outlet.
2. Practically frictionless and noiseless turning of the ventilator head, when the wind direction changes. The head should turn at very low wind velocities.
3. Smallest possible change of direction of the air ascending from the building and least possible resistance to its egress by louvres or other obstructions at the outlet opening.

C—All Ventilators.

1. Freest possible outlet for the air from the building, with large areas and smallest possible change of direction of the air flow.
2. Freedom from down drafts and from entrance of rain or snow.
3. Freedom from being rendered inoperative by collection of snow or formation of ice on ventilator.

The simplest form of ventilator, shown in Fig. 2, consists of an outlet pipe with a conical hood above it. The addition of a storm band, as shown in Figs. 3, 4, and 5, gives an increased protection against the entrance of rain or snow. The storm band, if placed so close to the cones as to restrict the outflow of air, interferes with ventilation. On the other hand, if the openings are made large enough to permit free egress of the inside air, the storm band increases the ventilation by better utilizing the wind velocity to produce suction.

A further development of the latter principle is the siphon ventilator, as illustrated in Fig. 6, in which siphons or ducts are introduced for the particular purpose of producing suction.

In the swiveling or rotary ventilators, typified by Figs. 7 and 8, a freely rotating cowl is used. A wind vane is provided for keeping the opening facing away from the direction of the wind. This type allows

free egress of the inside air (unless the outlet is made unduly small). Its action depends chiefly upon the suction produced by the wind on the leeward side of the ventilator.

In the induction or ejector type of ventilator, which is also of the swiveling or rotary type, Fig. 9, the kinetic energy of the wind is intended to create a suction inside the cowl as well as outside.

Resistance to flow of air in the ventilator is caused by; (1) restricted outlet openings, or (2) many turns or changes of the direction of the air

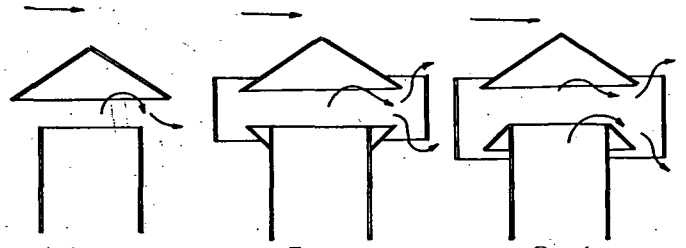


FIG. 2 FIG. 3 FIG. 4

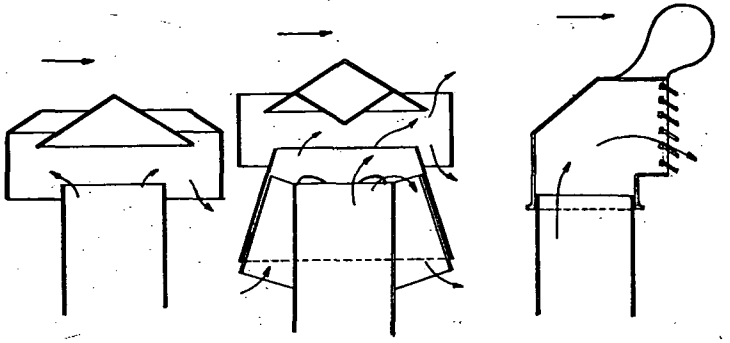


FIG. 5 FIG. 6 FIG. 7

VARIOUS STYLES OF ROOF VENTILATORS

flow. As regards the first item, this depends entirely upon the proportions, and not upon the type; some of the stationary ventilators have smaller, and others have larger outlet area than some cowl ventilators of the same nominal size. Regarding the second item, the swiveling cowl ventilators offer less resistance than the stationary type, in that the direction of air flow is changed as little as possible.

Unless swiveling ventilators move very freely, the opening, at times, faces towards the wind so that ventilation produced by temperature difference is much reduced, or wholly counteracted. In that case, snow and rain may blow in. The rumbling or creaking noise caused by a hard turning swivel ventilator is also very unpleasant. These troubles are,

of course, eliminated in well designed ventilators, but must be kept in mind.

In Fig. 10, is shown a rotary or air-turbine ventilator, which rotates continuously under the action of the wind, the motion being produced by the difference of wind pressure on the convex and concave sides of the

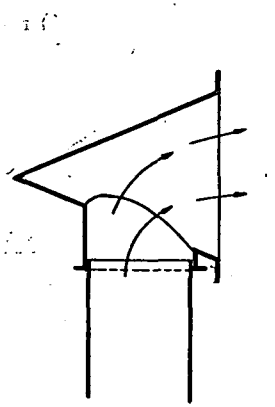


FIG. 8

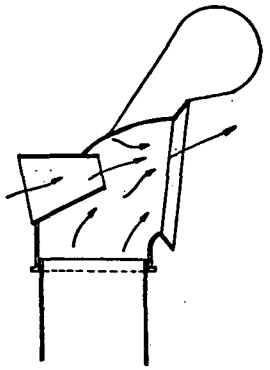


FIG. 9

ROTARY VENTILATORS

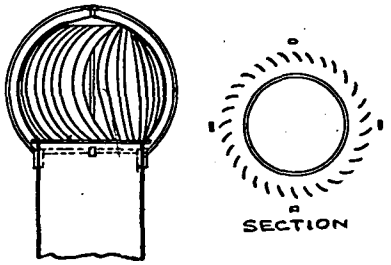


FIG. 10
AIR-TURBINE VENTILATOR

vanes. This type of ventilator must be very carefully designed if it is to be leak-proof, and if the noises and impact forces, due to ice accumulating on the vanes in the winter are to be eliminated.

CAPACITIES OF UNIT TYPE ROOF VENTILATORS

The variety of factors affecting capacity makes it essential for the user of ventilators to exercise great care in respect to the item of capacity. All comparisons of capacity must be referred to a given dimension, namely the throat area, corresponding to the nominal size of the ventilator.

Careful tests of ventilators of various types have been made by reliable investigators, and the reader is referred to their work for information on

capacities (See TRANS. A. S. H. & V. E., Vol. 27, 1921, p. 67; Vol. 28, 1922, p. 189; and Vol. 29, 1923, p. 39. Also Bulletin No. 14, Engineering Experiment Station, Kansas State Agricultural College).

Conservative figures for the best types of ventilators now on the market, under conditions of unrestricted flow of air to the ventilator, are given by the equation:

$$Q = A \times \left[\frac{36 \times \sqrt{H \times (t_i - t_o)}}{6 + V} + 20 \times V \right]$$

where

Q = cubic feet of air exhausted per hour through a ventilator having a free area at the throat of A square inches, mounted on a roof at a height of H feet from the center of the ventilator outlet to the inlet opening of the building, and with a wind velocity of V miles per hour, and average temperature t_i inside t_o outside.

High class ventilators, for instance those of the ejector type, will, under favorable conditions, discharge continuously 25 per cent more air than these conservative figures indicate. Capacities are lower, on the other hand, if ventilators of lower efficiency are used, or if the flow of air into or through the building is restricted, or if the ventilator is not exposed to the free sweep of the wind. Tests occasionally show considerably higher discharge rates over short periods of time. These abnormally high results are produced by the action of the wind upon certain openings of the building; they are not due to the ventilator itself, and cannot be depended upon for continuous ventilation if the direction of the wind changes. In the smaller sizes of ventilators (12 in. or less in throat diameter) the air discharge per square inch of cross-sectional area is reduced, on account of the frictional resistance and, in the rotary types, on account of reduction of free area by the supports, bearings, etc.

Example.—What is the capacity of an 18 in. ventilator, located 35 ft. above the inlet openings, with 6 miles per hour wind velocity, 50 deg. fahr. outside temperature, 68 deg. fahr. inside temperature?

Answer.—$A = 0.7854 \times (18)^2 = 255$ sq. in.

$$Q = 255 \times \left[\frac{36 \times \sqrt{35 \times (68 - 50)}}{6 + 6} + 20 \times 6 \right] = 50{,}000 \text{ cu. ft. per hour,}$$

average capacity under these conditions.

The air supply per person and per hour, or the number of the renewals of air contents per hour is given in Chapter I. (See also Chapter I under "Infiltration," and Chapter XXVI).

To obtain effective, uniform ventilation and avoid local drafts, the ventilators should not be placed more than 30 ft. apart; 20 ft. apart is a good average. It is best, although not absolutely necessary, to locate the ventilator at the ridge of the roof, unless the building exceeds 40 ft. in width, in which case two rows of smaller ventilators should be used. Where the building to be ventilated is surrounded by higher buildings

which obstruct air currents, it is desirable to extend the ventilators above the buildings by mounting them on stacks.

Example.—A foundry building is 40 ft. wide, 200 ft. long, with an average height of 40 ft.; the ventilators are to be mounted at the ridge of the roof, at a height of 55 ft. above the floor. What number and size of ventilators are required?

Answer.—In this case, ventilation is especially necessary in summer. The air in the building should not be over 10 deg. fahr. warmer than the outside air. The wind velocity may be as low as 4 miles per hour. Spacing the ventilators, tentatively, 25 ft. apart, 8 ventilators would be required. Under average conditions, 10 air renewals per hour are sufficient. If the foundry is small and cramped, and pouring takes place over a large section of the floor space, 15 or more air renewals per hour may be needed. On the basis of 10 renewals per hour, the capacity of each ventilator must be:

$$Q = \frac{10 \times (200 \text{ ft.} \times 40 \text{ ft.} \times 40 \text{ ft.})}{8} = 400{,}000 \text{ cu. ft. per hour}$$

The discharge per square inch of throat area under these conditions is;

$$\left[\frac{36 \times \sqrt{55 \times 10 \text{ deg.}}}{6 + 4 \text{ mi./hr.}} + 20 \times 4 \text{ mi./hr.}\right] = 165 \text{ cu. ft. of air per hour.}$$

The required throat area per ventilator is

$$\frac{400{,}000}{165} = 2420 \text{ sq. in.}$$

if there is no resistance and no wind pressure.

The diameter is $\sqrt{\frac{2420}{0.7854}} = 55.5$ in. Standard sizes are 54 in. and 60 in. Either eight—54 in. or else seven—60 in. ventilators could be used, spaced respectively 25 ft. or 28 ft. apart.

The foregoing is based on the use of high class ventilators. If ventilators of lower efficiency are used, or if the air flow into the building is restricted (as in winter) larger ventilators may be required.

CONTINUOUS TYPE OF ROOF VENTILATOR

The continuous type of roof ventilator is illustrated in Fig. 11. It furnishes a continuous opening in the roof throughout the length of the building, and is in effect a ridge louvre or monitor. It is stated that the high temperature of the air immediately beneath the sheathing, resulting from exposure of the roof to the sun's rays, induces a powerful convective effect along the pitched roof toward the opening which offers a direct avenue of escape, whereas in the unit type of ventilator, the free egress of the air is confined to definite points along the roof, and the natural upward flow is diverted with some loss, to a longitudinal movement. These ventilators are expected to function by the force of temperature difference alone, and have no external features designed to generate a suction by the action of the wind. The absence of a conspicuous external structure makes this type of ventilator particularly suitable for certain types of buildings.

DAIRY STABLE VENTILATION

Natural ventilation has an important application in dairy stables and other buildings housing live stock. A paper by F. L. Fairbanks, A. S. H.

& V. E. JOURNAL, February, 1928, offers valuable information on this subject. Some of the most important facts are stated below. Although they have been derived from a study of dairy stables, it will be found that some of them are general in their application:

1. For good ventilation, there should be provided about 3500 cu. ft. of fresh air per hour per 1000 lb. of live stock weight.

2. A strong convective circulation is generated by the heat from the bodies of the stock causing an upward movement toward the ceiling, about them, and a consequent downward movement at the walls.

3. Intake openings should be located in the walls near the ceiling so that incoming cold air, falling toward the floor, will accentuate the convective action induced by the heat within.

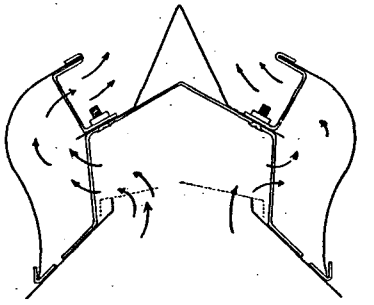


FIG. 11. CONTINUOUS TYPE ROOF VENTILATOR

4. Outlet openings seem to function merely as exhaust ports, to relieve the interior pressure, and appear to have little influence on the direction of air currents. Hence, the spacing or distribution of outlet openings is rather immaterial, so long as the required aggregate area is provided. Area of outlet openings should be about one-third greater than intake.

5. It is better to take the air out at the floor than at the ceiling since by the former there appears to be a larger volume of warm air held in the stable, which contributes to better temperature control.

6. The active circulation resulting from the down flowing cold air entering at openings in the walls near the ceiling, cooperating with the convective action induced by the heat of the animals, effectually prevents condensation and keeps the air fresh and odorless.

Fig. 12 illustrates a dairy stable ventilation system embodying the principles stated.

CONTROL OF VENTILATION

Control of natural ventilation depends upon hand regulation, which may be applied in two ways, *First*, by the selection of appropriate localities about the building at which to make openings, with regard to direction of the wind, and *Second*, by regulation of the amount of opening, which is accomplished by window operative devices, dampers, or louvres. Control may be effected by the regulation of either inlet or outlet openings, or both and for satisfactory results needs careful study and close attention.

APPLICATION OF NATURAL VENTILATION

Factory or industrial buildings are usually ventilated by natural forces, and most commonly by means of windows arranged in side walls and monitors of some form. The vast amount of openings made available by operative windows gives opportunity for unbelievably large air flow, even with forces of slight intensity.

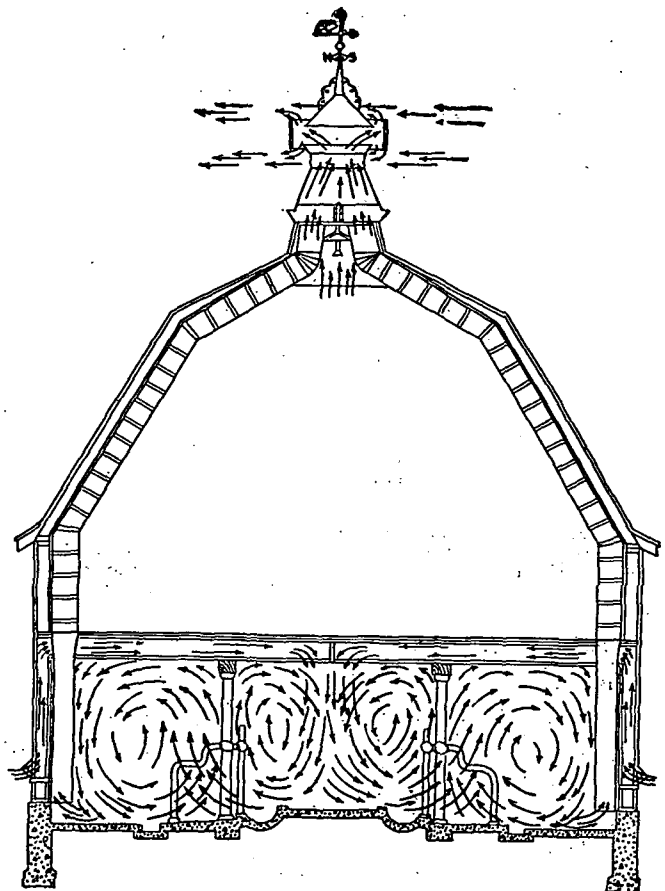


FIG. 12. ACTUAL AIR CIRCULATION AS DETERMINED BY VENTILATION INDICATOR

Roof ventilators are found on buildings of all kinds, particularly where fumes and gases are produced.

Dwelling houses are almost always ventilated by natural means, sometimes by roof ventilators, but more often by windows. In colder weather, practically the only ventilation in houses is by infiltration.

CHAPTER XXXIV

REPORTS, CODES AND STANDARDS OF THE A. S. H. & V. E.

(1) FLANGED FITTINGS

Standards for Flanged Fittings and Flanges, presented at annual meeting, January 1912. See A. S. H. & V. E. TRANSACTIONS, Vol. XVIII, p. 44.

(2) USE OF THE ANEMOMETER

Standards for Measuring Air Velocities at Air Supply Openings by means of the Anemometer, presented at annual meeting, January 1913. See A. S. H. & V. E. TRANSACTIONS, Vol. XIX, p. 202. (Not adopted). The following is a synopsis of this report:

Opening shall be divided into twelve equal squares or at least into equal squares not over 10 x 10 in. One-half minute readings shall be taken at the center of each square.

If the anemometer is held against the face of a register or the periphery of diffusers the volume of air shall be gotten by multiplying the average of the velocities by the net area through the grille or diffusers. If the anemometer is held 2 in. away from the face of the grille or diffusers no deduction shall be made for the area occupied by the material of the grille or diffuser.

(3) USE OF THE PITOT TUBE

Code for the use of the Pitot Tube, presented at annual meeting, January 1914. See A. S. H. & V. E. TRANSACTIONS, Vol. XX, p. 211. Adopted, January 1914. The following is a synopsis of this Code.

Pressure readings of 1 in. or less should be taken on an inclined tube type differential draft gage, graduated to at least hundreths of an inch, calibrated by a hook gage. Readings over 1 in. should be taken either with an Ellison type gage or with a U-tube graduated to at least tenths of an inch. Great care should be taken to have perfectly tight connections, especially on the static side.

The reading should be taken at a cross-section where the pipe is straight and the flow undisturbed. This should be preferably at least 10 diameters from the fan outlet, from an elbow, or from a change in cross-section in the duct.

The readings should be taken over a plane at right angles to, and the tube should be pointed in a direction parallel to, the direction of the air-flow.

In making a traverse of a rectangular duct the cross-sectional area may be divided into a number of smaller rectangles, and a reading taken in the center of each small rectangle.

A round pipe should be divided into at least three concentric zones of equal area per foot in diameter, and four readings taken on a circle drawn through the center of area of each zone or ring. That is, readings should be taken across the horizontal and vertical axis of the pipe.

The corresponding velocities for each of these readings should be determined and an average taken of all of these velocities in order to compute the air quantity. Inasmuch as the velocity varies as the square root of the pressure, accurate results cannot be obtained by averaging the pressure readings and taking the corresponding velocity as the average.

The velocity may be determined from the velocity pressure by use of the formula.

$$V = 1096.5\sqrt{\frac{P_v}{W}}$$

V = velocity in feet per minute.
P_v = pressure in inches of water.
W = weight of air in pounds per cubic foot under the existing conditions of temperature, barometer and humidity.

With dry air at 70 deg. and 29.92 in. barometer $W = 0.0749$ whence the formula becomes:

$$V = 4005\sqrt{P_v}$$

With saturated air at 70 deg. and 29.92 in barometer.

$$W = 0.0735$$

$$V = 4046\sqrt{P_v}$$

(4) SYNTHETIC AIR CHART

Ventilation Standards and Synthetic Air Chart. Presented at the semi-annual meeting 1917. See A. S. H. & V. E. TRANSACTIONS, Vol. XXIII, p. 607.

The following gives a brief description of the Synthetic Air Chart and method of using same. The form of this Chart has been slightly modified since it was adopted by the Society and the form here presented is the one in use at the present time.

Description of the Chart

The Synthetic Air Chart is designed for measuring the air conditions maintained in a room. Instead of speaking of the ventilation of a room as good, bad or indifferent, the results of tests are plotted on a chart, and the air conditions as a whole determined on a percentage basis. (Fig. 1.)

This is done by plotting test data for all known factors that make up the air conditions. These factors with their proper weights are arranged in vertical columns across the chart.

The base of each column represents ideal conditions, or 100 per cent perfect. The columns are seven in number, and the first six are indicated by the capital letters, *A*, *B*, *C*, *D*, *E*, *F*.

A = the Effective Temperature Difference, or the amount of variation from the ideal effective temperature.
B = Dust Particles per Cu. Ft.
C = Bacteria.
D = Percentage of freedom from objectionable odors.
E = Carbon Dioxide, parts per 10,000.
F = the Distribution Percent.

The last column is the Percent of Perfect column used for plotting the final percentage.

Each of these main columns is further divided into three smaller columns, the center one of which is left blank for recording the test data. To the left of this is the scale for the individual factor, effective temperatures in degrees, dust in particles per cubic foot, carbon dioxide in parts per 10,000, etc. On the right of each central column is the penalization scale. This is arranged with main graduations of 1 per cent which are numbered. Each graduation is further subdivided into 5ths so that the scale may be read to 0.2 of 1 per cent on the scale, or by interpolation to 0.1 per cent.

The chart gives not only final percentage of the test as a whole, but also indicates at a glance which factors are satisfactory and which at fault. In this way it is a convenient guide in correcting bad conditions, and bringing the final percentage up to the point desired.

Making the Test

In making a Synthetic Air Chart test the observer first divides the room by imaginary lines into small sections, each section having an area of approximately 200 sq. ft. of floor space. He locates an observation station in the center of each section. Taking a

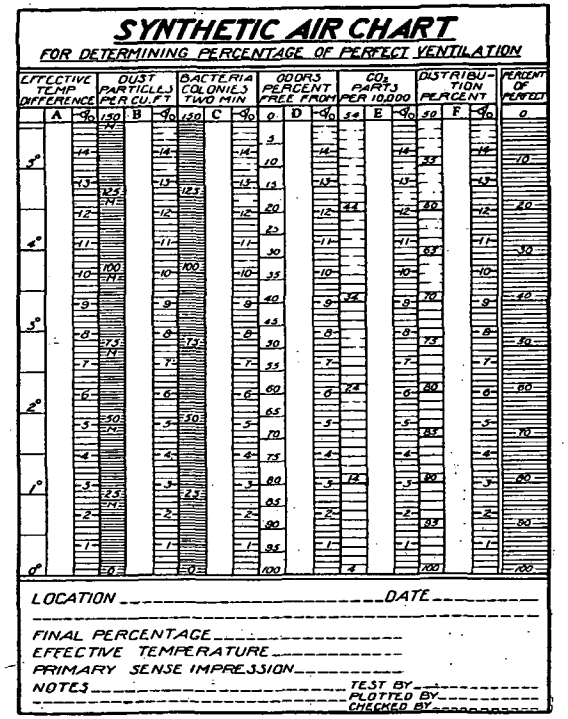


FIG. 1. SYNTHETIC AIR CHART

school classroom for example, the room should first be divided into four equal rectangular areas by imaginary lines bisecting at right angles through the center of the room. (*See* Fig. 2.) Four stations are now selected, one at the center of each rectangle. These stations are numbered *1*, *2*, *3* and *4*. It is always well to use a standard method of numbering stations, so that whoever reads the report can visualize each location.

Standing at the rear of the room facing the teacher's desk *No. 1* is the station nearest the teacher at her right. *No. 2* is the one directly back of *No. 1*. *No. 3* is the station nearest the teacher at her left, and *No. 4* the remaining station.

The tests are conducted in the following manner:

Column A.—A Psychrometer reading is taken at each station beginning with *1*, following with *2*, *3* and *4*. The wet and dry bulb readings are separately recorded on the data sheet, Fig. 3, for each station.

Column B.—Dust determinations are next made at stations *1, 2, 3 and 4*, and the count of particles per cubic foot recorded from each station. The scale of the chart is arranged for a direct reading dust counter. If some other type of instrument is used, a correction factor is, of course, necessary.

Column C.—Culture plates are next exposed to determine the bacterial content of the air. One plate is exposed at each station for two minutes, incubated, and the colonies that develop are counted and recorded for each plate. The average of all plates is plotted on the chart.

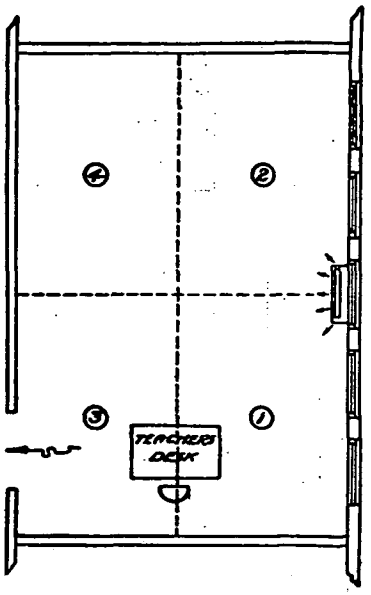


FIG. 2. STATIONS FOR MAKING TEST

Column D.—Odor determinations are made of the room as a whole.

The observer should go outside of the room or preferably outside of the building for a few moments previous to making the test. He then enters the room quickly, and makes his determinations of the air in the classroom by means of the olfactory sense, recording the results whether perfect, very faint, noticeable, etc., in accordance with the following table.

Freedom from Odors

100%	95%	90%	85%	80%	75%	70%
Perfect	Very Faint	Faint	Noticeable	Distinct	Decided	Strong

An Odorometer consists of a case of six vials each containing an odor substance in varying strength. It adds materially in classifying and standardizing odor perception. Its use, however, is not imperative.

Column E.—Samples of air are next taken at each station, and later analyzed for carbon dioxide, and results of this analysis plotted in *Column E* in parts in 10,000.

Column F.—Distribution of the air in the room is determined from the CO_2 analysis taken at the various stations.

The following example illustrates the method of making the calculation:

Stations	CO_2	Stations	Variations from the Average
1	11.1	1	11.1 − 10.2 = 0.9
2	9.4	2	10.2 − 9.4 = 0.8
3	10.4	3	10.4 − 10.2 = 0.2
4	9.9	4	10.2 − 9.9 = 0.3
Total	40.8		Total 2.2
Average	10.2		Average 0.55

$$\frac{0.55 \times 100}{10.2} = 5.4 = \text{per cent of variation.}$$

$100 - 5.4 = 94.6 =$ final per cent of distribution.

TEST DATA

BUILDING ____ DATE ____
ROOM ____ FLOOR ____ TIME ____ TO ____

STATION	TEMPERATURE DRY BULB	TEMPERATURE WET BULB	R.H.%	AIR MOTION	DUST	BAC-TERIA	ODORS	CO_2	SUPPLY REGISTERS AREA #	SUPPLY REGISTERS VELOCITY	SUPPLY REGISTERS C.F.M.	EXHAUST REGISTERS AREA #	EXHAUST REGISTERS VELOCITY	EXHAUST REGISTERS C.F.M.
1														
2														
3														
4														
5														
6														
7														
8														
9														
10														
11														
12														
13														
14														

PRIMARY SENSE IMPRESSION. NOTES.

NO. OCCUPANTS		WINDOWS NO.	RADIATORS	TYPE	HEATER.
PHYSICAL STATE		TYPE	TYPE, SQ. FT.		TEMP. DRY ____ WET ____ R.H.%
AIR SPACE PER OCCUPANT		AREA			WIND DIR. ____ VEL. ____ M.P.H.
TOTAL AIR SUPPLY BY CO_2		LEAKAGE			TEST BY
AIR SUPPLY PER OCCUPANT BY CO_2		RATIO — CO_2 CONTENT			CHECKED BY
" " " " " FAN		FLOOR AREA PER PERSON			APPROVED
AIR DISTRIBUTION %					

FIG. 3. DATA SHEET FOR SYNTHETIC AIR CHART TEST

After the tests have been made as described, the observer completes his test by a study of air motion and air currents. This is done by liberated puffs of ammonium chloride in different locations in the room with a suitable apparatus. Observations of the velocity and direction of travel of these small artificial smoke clouds add materially in obtaining a true conception of the velocity and general behavior of the air currents in the room.

Plotting the Test Data

The results of the tests are plotted in each column as previously described. The following data from the test illustrated on the chart on page 485 will make the entire procedure clear:

Average Dry Bulb temp. 75 deg.—Wet Bulb temp. 59.7 deg.—Effective temp. 67.4 deg.

Effective temp. Dif. 3.4 deg.—Plot in Column *A*.
Aver. Dust Count for 4 Stations—7000 particles per cu. ft.—Plot in Column *B*.
Aver. Bacteria for 4 Stations — 3.5 —Plot in Column *C*.
Aver. Odors Percentage — 90 per cent —Plot in Column *D*.
Aver. CO_2 — 10.2 —Plot in Column *E*.
Distribution Per Cent — 94.2 per cent —Plot in Column *F*.

Adding the penalization for these factors found at the right of each column and subtracting the sum from 100 gives a final percentage of perfect of 84.7, which is plotted in the last column.

(5) CODE OF ETHICS

Code of Ethics for Engineers, presented at annual meeting, January 1922. See A. S. H. & V. E. TRANSACTIONS, Vol. XXVIII, p. 6. Adopted, January 1922. See also page xii of this GUIDE.

(6) CODE FOR TESTING FANS

Standard Code for the Testing of Centrifugal and Disc Fans adopted at semi-annual meeting, May 1923. See A. S. H. & V. E. TRANSACTIONS, Vol. XXIX, p. 407.

(7) CODE FOR TESTING HEATING BOILERS

Code for Testing Low Pressure Steam Heating Boilers adopted at annual meeting, January 1924. See A. S. H. & V. E. TRANSACTIONS, Vol. XXX, p. 9.

(8) WARM AIR FURNACE CODE

Standard Code Regulating the Installation of Gravity Warm Air Furnaces in Residences. See 1925-26 Edition A. S. H. & V. E. GUIDE, p. 151.

(9) CODE OF MINIMUM REQUIREMENTS

Code of Minimum Requirements for Heating and Ventilating Equipment of Buildings, adopted 1925 and printed in book form and in separate sections as follows:

Section Appendix 1.
1. Ventilation Requirements for Public Buildings.
2. Requirements for Heating Buildings.
3. Direct Steam or Hot Water Radiation.
4. Indirect Steam or Hot Water Radiation.
5. Heating Boiler Capacity.
6. Warm Air Furnace Heating.
7. Design of Chimneys and Flues.
8. Pipe Sizes for Steam Heating.
9. Pipe Sizes for Hot Water Heating.
10. Air Ducts for Ventilation.
11. Air Washers and Humidifiers.
12. Pumps for Heating Systems.
13. Definition of Terms.

Appendix 2. Standard Symbols for Drawings.

TENTATIVE CODES

1. Tentative Code for Testing Insulating Materials.
2. Tentative Code for Testing Radiators.

CODES UNDER DEVELOPMENT

The following Codes and Standards are in course of development.

1. A Revised Code for the Testing of Low Pressure Steam Heating Boilers.
2. Standard Code for the Rating of Low Pressure Heating Boilers.
3. Standard Code for Measuring the Heat Transmission of Building Construction.
4. Standard Code for Testing Air Cleaners.

CONSULTING SERVICE SECTION

DIRECTORY OF ENGINEERS

Specializing in Heating and Ventilating Work

ARRANGED ALPHABETICALLY

A. R. ACHESON

Consulting Engineer

Heating and Ventilation
Power Plant Designs
Electrical Engineering

601 Eckel Building

Syracuse, N. Y.

ALPHONSE A. ADLER
M.E., Sc.D.

Consulting Engineer

9 Murray Street

New York, N. Y.

ESTEN BOLLING, M.E.

Consulting Engineer

Technical Publicity
Sales Development

Box 46

East Orange, N. J.

THOS. CHESTER

Air Conditioning, Cooling,
Dehumidifying

1318 Cordova Road

Pittsburgh, Pa.

SAMUEL E. DIBBLE

Consulting Engineer

Heating, Ventilating and
Plumbing

415 Hastings Street

Pittsburgh, Pa.

THE FROST RESEARCH
LABORATORY

Robinson V. Frost, C.E.
Director

A consulting research service
in
Heating and Ventilating

1326 Markley Street

Norristown, Pa.

LEE P. HYNES

Electric Heating Engineer

Design and Construction of
Electric Heating and Control

Electric Unit Air Heaters
Electric Water Heating
Electric Steam Boilers
Off Peak Power Utilized
Industrial Process Work

30 Church Street

New York, N. Y.

JAROS & BAUM

Consulting Engineers

for

Mechanical Equipment of
Buildings

116 West 39th Street

New York, N. Y.

ALFRED KELLOGG

Engineer

Designing - Consulting

Public Building Engineering
Power Plants

Investigations, Appraisals
and Reports

89 Franklin Street

Boston, Mass.

CARL J. KIEFER

Consulting Engineer

Member A. S. M. E.
Member A. S. H. & V. E.

Mechanical - Heating
Ventilating

Sanitary Equipment Designs

Schmidt Building

Cincinnati, Ohio

RICHARD D. KIMBALL CO.

Engineers

Heating and Ventilating
Electrical
Sanitary

Central Plants a Specialty

6 Beacon Street

Boston, Mass.

A. S. LAU

Mechanical Engineer

51 East 42nd Street

New York, N. Y.

SAMUEL R. LEWIS

Engineer for Mechanical Equipment of Buildings

407 S. Dearborn Street

Chicago

MENSING & CO.

Consulting Engineers

Presser Building

Philadelphia, Pa.

ROBERT P. SCHOENIJAHN, M.E.

Consulting Engineer

Industrial Trust Building

Wilmington, Del.

WEBSTER TALLMADGE & CO., INC.

Specialists in Steam Engineering

High Efficiency Heating with Zoned Electrical Control

Emergency Engineering Service

Heating Surveys

50 Church Street

New York, N. Y.

PERRY WEST, M.E.

Consulting Engineer

13 Central Avenue

Newark, N. J.

Consulting Service Cards

are

Profitable

CATALOG DATA SECTION

(Pages 495–818)

with an

INDEX TO MODERN EQUIPMENT

(Pages 819–840)

and

INDEX TO ADVERTISERS

(Pages 841–844)

Bentz Engineering Corporation

Apparatus for Temperature and Humidity Control
for every Industrial Air Conditioning Requirement.

DRYING — REFRIGERATION

Newark, N. J.

Offices

NEW YORK	122 Greenwich St.	BOSTON	Park Square Bldg.
CHICAGO	Builders Bldg.	LONDON	92 Fenchurch St., E. C.

"CHILLBLAST"
(Reg. U. S. Patent Office)

Air Conditioner, Cooler and Dehumidifier

The choice of discriminating Engineers.
Selected by many after comparative tests.
Construction rugged, dependable and compact.
Noted for simplicity of design and economy of operation.
Refrigerating coils and impinging surfaces in path of the air, assuring maximum efficiency.



The "Chillblast" installed in a Candy Factory Packing Room

Bentz Cataract Type Air Washers and Conditioners
Essentially the same as the "CHILLBLAST" but without refrigerating coils.
Large impinging surface results in most effective scrubbing of the air.

Bentz Unit Air Conditioner
Suitable for installations where a central plant is not desirable.

Bentz Spray Type Air Washers and Conditioners
Manufactured in all sizes in accordance with standard specifications for Spray Type Apparatus.

Carrier Engineering Corporation

Atmospheric Conditioning Corporation

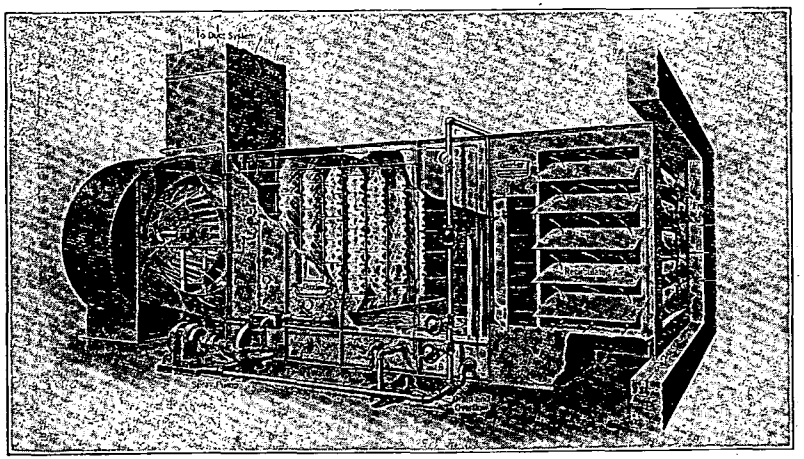
Offices and Laboratories: 850 Frelinghuysen Ave.

Newark, N. J.

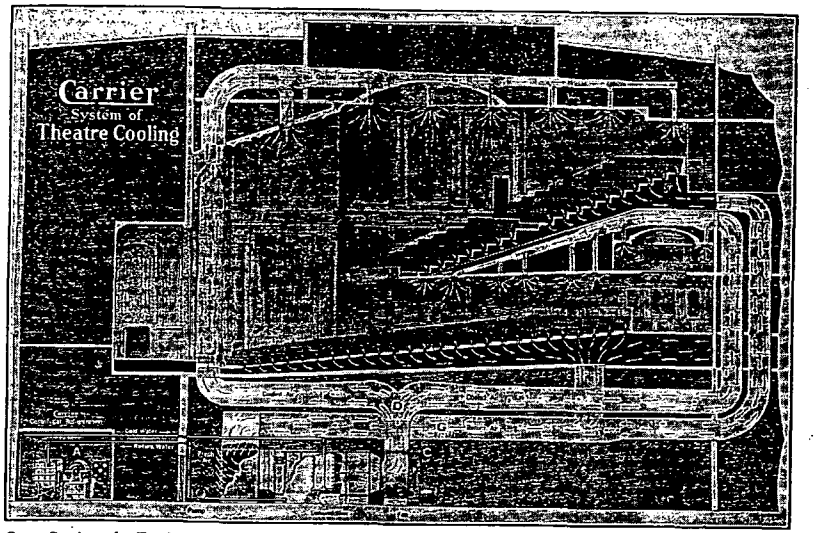
BOSTON, 1011 Statler Building — NEW YORK, 39 Cortlandt Street — CHICAGO, Burnham Building
CLEVELAND, Union Trust Building — PHILADELPHIA, Land Title Building
KANSAS CITY, Manufacturers Exchange Building — LOS ANGELES, 911 Mateo Street
WASHINGTON, D. C., 418 Washington Loan & Trust Building

Air Conditioning Systems—Especially designed for Textile Mills, Candy Factories, Bakeries, Flour Mills, Drug and Chemical Plants, Printing and Lithographic Plants, Packing Plants, Laboratories, Theatres, Public Buildings, and for numerous other industries where there are requirements for clean air uniformly distributed and automatically controlled at any desired condition of temperature and humidity. Equipment, installation and results are guaranteed. *Ask for Bulletin 58-G, or request specific information.*

Cooling and Air Conditioning in Public and Private Buildings—With a background of more than twenty-five years' experience in the design and application of Air Conditioning equipment, the Carrier organization has logically led in applying this science to the maintenance of conditions of physical comfort of people congregated within buildings. In Theatres, Auditoria, Hospitals, Hotels, Department Stores, Office Buildings, Factories and Mansions it is now possible to maintain ideal conditions of physical comfort, regardless of seasons or outdoor weather. Winter conditions require humidification and heating. In Summer, cooling and dehumidification must be accomplished. Nearly 3000 Carrier installations in more than 200 different industries are producing the desired conditions unfailingly. We are at all times pleased to cooperate with Architects, Engineers and Builders in the design and installation of Air Conditioning equipment within buildings under their direction. *Write for the book, "Theatre Cooling," G-1.*

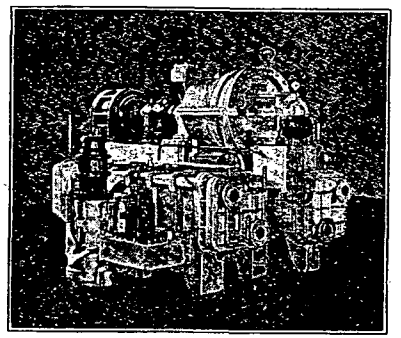


A Typical Carrier Humidifier or Dehumidifier showing the automatically controlled fresh and return air dampers, the spray chamber with pumping and water heating equipment and, on the left, the fan which delivers the air to the duct system



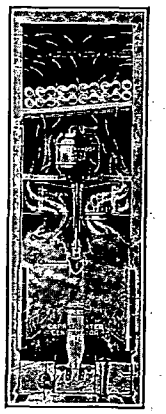
Cross Section of a Typical Theatre equipped with a Carrier System for Cooling, Dehumidifying and Purifying the Air in Summer, and Warming, Humidifying and Purifying the Air in Winter. Note the use of Carrier Centrifugal Refrigeration in connection with this equipment

Carrier Centrifugal Refrigeration—This system is an innovation in the production of cold. The refrigerant is a harmless, inoffensive liquid—"Carrene." The compressor is a simple centrifugal unit similar in construction and operation to a centrifugal pump. Control is automatic. Space requirement is one-quarter that of any other system of like capacity. This system is used in connection with all Carrier cooling and dehumidifying installations. Complete safety, simplicity and efficiency of operation are assured. *Details on request.*



A Complete Carrier Centrifugal Refrigeration Unit. Safe. Simple. Automatic

The Carrier Unit Air Conditioner—A simple, efficient, compact, portable and inexpensive Unit which performs every function of the Carrier Central Station System. It washes the air, cools, heats, humidifies, dehumidifies and produces effective ventilation and air circulation. Capacity 2,500 cu. ft. of conditioned air per minute. Entire operation by 1 hp. motor. This is not a miniature humidifier copied from the central station equipment, but is an entirely new and novel design developed to place *Manufactured Weather* within the means of *any* manufacturer. *Ask for "The Carrier Unit Air Conditioner," Bulletin 52-G.*



The Cooling & Air Conditioning Corp.

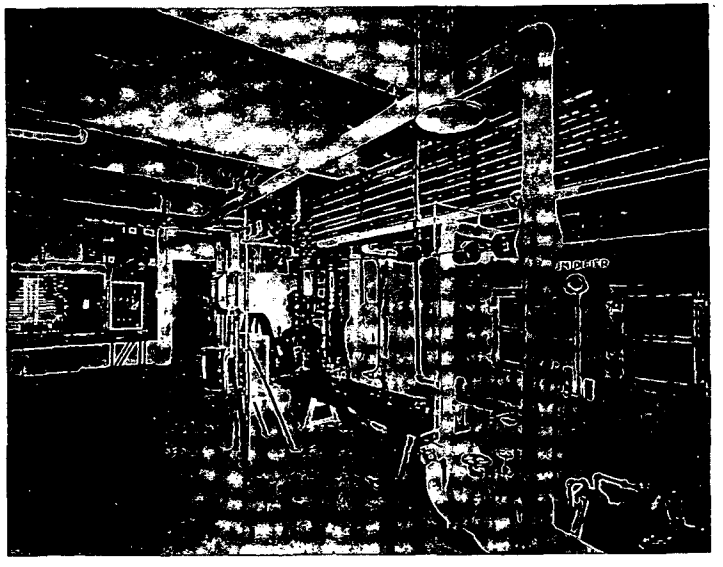
Executive Office

11 West 42nd Street
New York City

BOSTON
CHICAGO
ATLANTA
PITTSBURGH

Engineers and Contractors

Automatically Controlled Air Conditioning Systems: Cooling—Humidifying—Dehumidifying — Heating — Ventilating — Drying — Ross Paper Conditioning — Fleisher Bakery Systems



Complete Dehumidifying Equipment

Air Conditioning Systems are designed to overcome the handicaps imposed on industry by variations in weather, or adverse climatic conditions. They insure to the manufacturer that effect on materials and processes which can only be produced by ideal temperature and humidity values, making his plant entirely independent of the seasons or changeable daily weather.

Whether the cure for such difficulties involves the creation of high or low temperatures and high or low humidities in any combination, this organization offers a broad experience in the careful design of dependable equipment united with the highest type of engineering and contracting service.

In addition to the treatment of industrial departments requiring humidifying or dehumidifying, the cooling of theatres, moving picture houses, cafes, and other places of assembly are fields in which we have specialized with marked success.

The experienced active personnel of this organization enables us to design and install automatically controlled cooling and air conditioning equipments of any size, for any purpose and having had broad experience in practically all fields where this type of equipment is employed, our sales engineers will be glad to cooperate with those requesting their service.

Niagara Blower Company

AIR ENGINEERING PRODUCTS AND SYSTEMS

Factory and Engineering Office—673 ONTARIO ST., BUFFALO, N. Y.
Sales Office - - - - - - - - - - - - 95 LIBERTY ST., NEW YORK CITY

Air Conditioning, Humidifying, Dehumidifying, Heating, Cooling, Ventilation Equipment. *Niagara Air Conditioner, Niagara Fan Heater.* Drying, Dehydrating, Solvent Recovery, Pneumatic Conveying Systems. Niagarifin Heating Surface. Corrosion Resisting Equipment for Industrial Processes.

NIAGARA AIR CONDITIONER

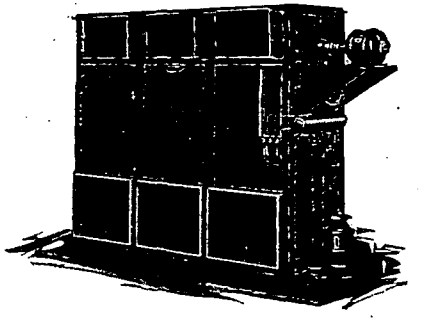
Manufactured for long life and efficient operation, these units offer all the advantages of air conditioning-controlled humidification and dehumidification and constant desired conditions of temperature and relative humidity automatically maintained as required for manufacturing processes or for human comfort.

Advantages—

Simplification of all air conditioning applications with standardized apparatus. Avoids the need for complicated and expensive air distributing systems.

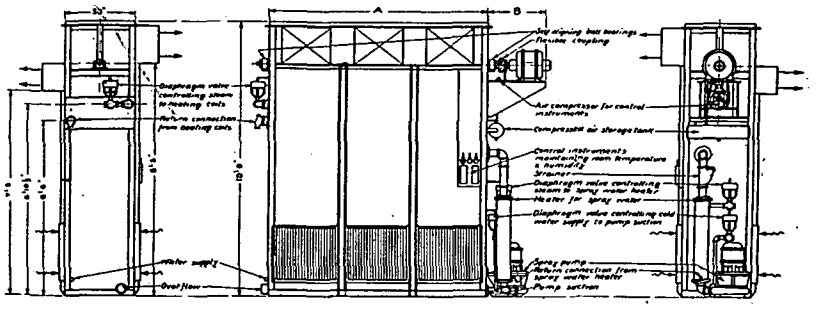
Flexibility in Arrangement, Location and Capacity—

Units can be moved with other equipment in plant changes and additional units can be used to provide increases in capacity.



Unit No.	*125 160 161	**225 260 261	***325 360 361
A	40"	70"	94"
B	22"	25"	27"

*1—Fan Unit. **2—Fan Unit. ***3—Fan Unit.



Niagara Air Conditioner

RATED OUTPUT CAPACITIES—Steam at 5 lb. Gage Pressure

Unit No.	Fan Motor		Pump Motor		S. P. In. Water on Fan Discharge	Cu. Ft. Air per Min. Saturated at 60 deg.	Lb. Air per Min.	*Capacity No. Cu. Ft. Contents — Thousands	Ventilation Persons at Work No.	Equivalent in Direct Radiation Sq. Ft.
	R.P.M.	H.P.	R.P.M.	H.P.						
AC 125	720	1	1440	2	0.0	3250	244	16 to 48	65	830
AC 160	860	2	1730	2	0.0	3900	292	19 to 57	78	920
AC 160	860	2	1730	2	0.2	3500	262	17 to 51	70	860
AC 161	1160	3	1730	2	0.2	4400	330	22 to 66	88	980
AC 225	720	2	1440	3	0.0	6250	468	31 to 93	125	1650
AC 260	860	3	1730	3	0.0	7500	562	38 to 114	150	1800
AC 260	860	3	1730	3	0.2	6900	517	35 to 105	138	1720
AC 261	1160	5	1730	3	0.2	8500	638	42 to 125	170	1920
AC 325	720	2	1440	3	0.0	8750	656	44 to 132	175	2310
AC 360	860	5	1730	3	0.0	10500	787	52 to 156	210	2600
AC 360	860	5	1730	3	0.2	9600	720	48 to 144	192	2480
AC 361	1160	7½	1730	3	0.2	12000	900	60 to 180	240	2800

Units Nos. 125, 225 and 325 are for 25-cycle current.

Units Nos. 160, 161, 260, 261, 360 and 361 are for 60-cycle current.

*The cubic feet contents of a room which an air conditioning unit will handle is dependent upon the relative humidity and the amount of heat to be absorbed (from lights, power consumed in running machinery or other source of heat)—the higher the humidity and the greater the amount of heat, the less room space in cubic feet contents with a given sized unit handle. The capacities given are only to serve as a rough guide for average conditions; even then the capacity may vary over a wide range as given.

Flexibility in Control—

The Units permit maintenance of different atmospheric conditions in different departments.

Convenience and Economy of Installation—

Units are shipped assembled ready for installation by connection to steam, fresh air, water and electric lines. Units require minimum of floor space.

Economy in Operation—

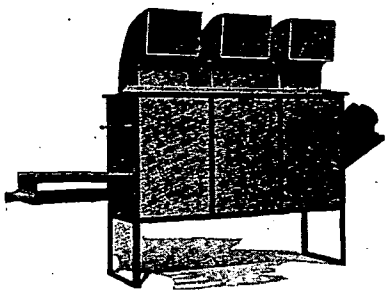
Heating, ventilating and air washing are included in unit's operation. Controlled for maximum steam economy. Places warm air immediately where needed.

Special Processes—

Units are easily arranged for use with any special plant processes where materials must be brought to a required condition of moisture as in drying or moistening cabinets.

Engineering Service—

This company, because it is primarily interested in the results secured by its equipment, makes available the most expert engineering service for air conditioning applications, assuring the user of the best advice in connection with the original installation and with changes for use in layout and equipment for new methods of processing.



NIAGARA FAN HEATER

For the heating and ventilating of industrial plants, foundries, machine shops, garages, assembly floors, large areas and high ceiling buildings. Especially adapted to conditions where ventilating as well as heating is required—packing plants, laundries, dairies, dye houses, paper mills.

Put the Heat Immediately Where Needed—

Niagara Heating Units cut the time required to bring a room to working temperature by delivering the warm air

immediately into the working zone. They maintain uniform temperature, leaving no cold spots or corners and draw the cold air off the floor without creating drafts.

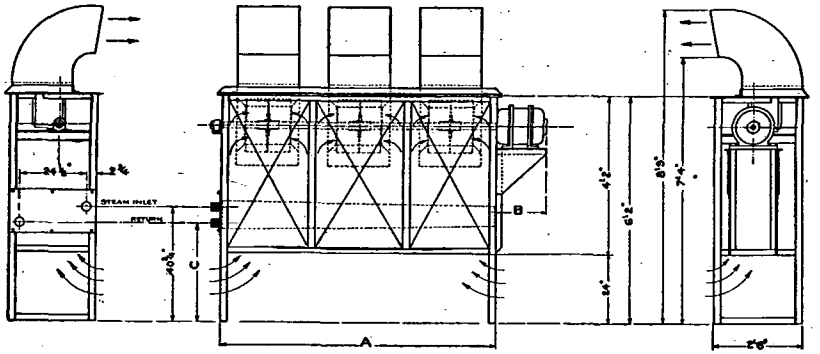
Efficient Heating—

By recirculating air in the working zone, Niagara Heating Units prevent the waste of heat caused by overheating the upper part of the room to obtain normal temperature below. Because of this saving and the large amount of air handled in relation to the heating surface, Niagara Heating Units consume less fuel in maintaining desired uniform temperatures.

Construction Advantages—

Specially designed, high efficiency fan produces large capacity with slower speed and more quiet operation. Niagarifin Heating Surface combines advantage of welded steel pipe construction and fin distribution of heat.

Unit No.	125 126 160 161	225 226 260 261	325 326 360 361
A	40"	70"	94"
B	21"	23"	25"
C	34¼"	33¼"	32¼"



Niagara Fan Heater

RATED OUTPUT CAPACITIES

Unit No.	R.P.M.	H.P. Motor	Recirculating Air—60 Deg. Entering Unit 5 Lb. Steam Pressure					*Equivalent in Direct Radiation Sq. Ft.
			Cu. Ft. Air per Min.	Lb. Air per Min.	Final Temp. Deg. Fahr.	B. T. U. per Hr.	Lb. Cond. per Hr.	
125	720	1	4340	295	124	274000	277	1190
160	860	1	4340	295	124	274000	277	1190
126	720	1	4400	295	132	308000	311	1340
161	860	1	4400	295	132	308000	311	1340
225	720	2	8680	590	124	542000	554	2380
260	860	2	8680	590	124	542000	554	2380
226	720	2	8800	590	132	616000	623	2680
261	860	2	8800	590	132	616000	623	2680
325	720	3	12600	855	124.5	800000	808	3475
360	860	3	12600	855	124.5	800000	808	3475
326	720	3	12800	855	132.6	900000	909	3910
361	860	3	12800	855	132.6	900000	909	3910

*Niagara Fan Heater will heat a building with a minimum saving of 10 per cent in B.T.U. or steam required for heating compared with direct radiation. This factor has been taken into account in giving the equivalent in square feet of direct radiation.

Units Nos. 125, 126, 225, 226, 325 and 326 are for 25-cycle current.

Units Nos. 160, 161, 260, 261, 360 and 361 are for 60-cycle current.

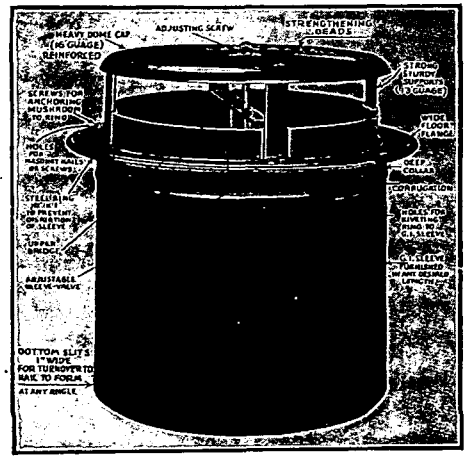
Charts, showing final temperatures, also B.T.U. output, at inlet temperatures from—20 to 160 deg. fahr. and at steam pressures from 2 to 200 lb., are available on request.

Knowles Mushroom Ventilator Co.

202-204 Franklin Street, New York

Knowles Air Diffusers for Auditoriums of Theatres, Churches, Schools

PRODUCTS:—Cast Iron and All-Steel Adjustable Mushroom Ventilators; Aisle Hood, Tu-Way and Camelback Air Deflectors; Round and Oblong Gallery Riser Vents.



Knowles *Aero Valve*—The Improved Mushroom Air Diffuser

The newest Knowles product. An up-to-date mechanically correct air unit of fixed height made of heavy rolled steel. Easy to regulate and install, and low in price.

Combines maximum efficiency with convenient adjustment affording finest control of air by simply turning screw on top of cap. Provided with or without sleeve and protecting steel ring. Same capacity as NU-NOTCH. (See booklet for detail).

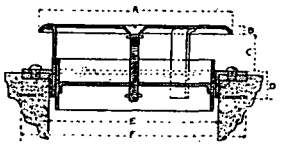
Specifications—(For Unit No. 1)—Furnish and install, where indicated on drawings or as hereinafter specified [6-in.] [8-in.] AEROVALVE Mushroom Air Diffusers with adjustable air regulator complete, known as Unit No. 1 as manufactured by Knowles Mushroom Ventilator Co., New York, N. Y. (See sleeve specification form below.)

For Unit No. 2—Furnish and install where indicated on drawings or as hereinafter specified [6-in.] [8-in.] AEROVALVE Mushroom Air Diffusers with adjustable air regulator complete with galvanized iron sleeve 6 in. long known as Unit No. 2 as manufactured by Knowles Mushroom Ventilator Co., New York, N. Y.

The sleeves are to be set by the Heating Contractor in conjunction with the General Contractor at the time the floor is laid, and just before the seats are placed the AEROVALVE Mushrooms are secured to the sleeve rings by three machine screws furnished in the holes provided.

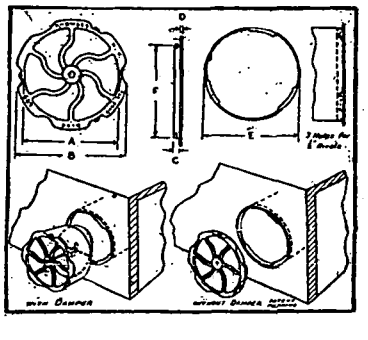
NOTE.—If preferred, we will furnish the Sheet Metal Contractor with the steel rings separately to attach to his own galvanized iron sleeves in the rivet holes provided. The NU-NOTCH Mushrooms may also be anchored to these steel rings in sleeves in 6 in. and 8 in. sizes only.

Size In.	A In.	B In.	C In.	D In.	E In.	F In.	G In.	Wgt. Lbs.	Area Sq. Ft.
6	6¾	¼	1½	1	6	8	1½	1½	0.1964
8	8¾	¼	2	1	8	10	2	2½	0.3491



Knowles *Disc-Loc* Gallery Riser

Ventilators are designed to insure better control of air. Round holes in the gallery risers do not weaken the construction but, on the contrary, with the cast iron rings it is actually strengthened. The sleeve is a plain galvanized iron cylinder, with a ½ in. turnover flange, and with a special cast iron ring, riveted flush to the inside front

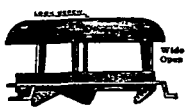


Size No.	Dimensions, In., Disc-Loc						Net Area Sq. Ft.	C.f.m. at 300 Velocity
	A	B	C	D	E	F		
4	3¾	5⅛	7/16	⅛	4¾	4	0.08	24
5	4¾	6¼	½	⅛	5⅝	5	0.13	39
6	5¾	7⅜	½	⅛	6⅞	6	0.19	57
7	6⅞	7⅞	1¼	⅛	7⅞	6⅞	0.24†	72

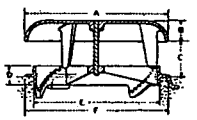
With or without regulating damper. †Square grill.

end. Sleeves are grouted in when concrete is poured. The cast iron grill is quickly inserted and locked by a simple twist motion—no bolts, screws or springs. Furnished with or without damper to fit same rings.

Knowles *Nu-Notch* Mushroom Ventilator or Air Diffuser



The ideal cast iron mushroom. Head has three outer bearings and is absolutely rigid. Ten recessed notches give close regulation of air. Locked into positive adjustment by tightening head screw. Supplied with dome or flat tops. Three screwholes in floor flange for fastening to wood, or three steel L lugs for setting in concrete, or three set-screws in floor collar for fastening to sleeve.



Specifications—Furnish and install where indicated on drawings or as hereinafter specified [5-in.] [6-in.] [7-in.] [8-in.] [10-in.] [Dome Top] [Flat Top] NU-NOTCH Cast Iron Mushroom Air Diffusers with recessed notches for the permanent adjustment of mushroom caps at any desired opening together with center locking screw feature as manufactured by Knowles Mushroom Ventilator Co., New York, N. Y.

Provide under each air diffuser one No. 20 galvanized iron sleeve to be set by the heating contractor in conjunction with the general contractor at the time the floor is laid. In concrete floors when sleeves are located on forms fill sleeves with sand before being grouted in to prevent their distortion.

For wood floors: attach the mushrooms to the floor by means of flat head screws. For concrete or similar type floors: by tightening 3 set-screws in the collar, or by embedding 3 L lugs in cement or by screwing to Knowles Sleeve rings. (In your specification indicate the desired size, style of top and method of attachment).

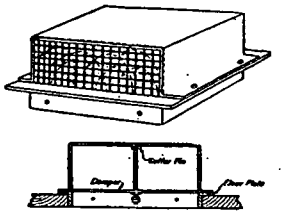
Size No.	A In.	B In.	C In.	D In.	E In.	F In.	Weight Lbs.	Area Sq. Ft.	C.f.m. at Velocity of				
									200 ft.	250 ft.	300 ft.	350 ft.	400 ft.
5	6	7/8	1¾	1⅝	5	6	4	0.1364	27.3	34.2	41.0	47.7	54.6
6	7⅛	1⅛	1½	1½	6	7⅛	4¾	0.1964	39.3	49.1	59.0	68.7	78.6
7	8¼	1¼	2⅛	1¼	7	8¼	6½	0.2573	53.5	66.8	80.2	93.5	107.0
8	9⅜	1½	2	2	8	10⅛	9	0.3491	69.8	87.3	105.0	122.0	140.0
10	11½	1⅝	3	2½	10	11⅞	14½	0.5454	109.0	136.3	163.6	191.0	218.0

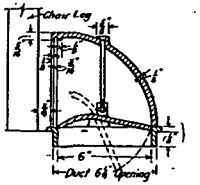
Tu-Way Air Deflectors

are designed to give maximum area of discharge of air with minimum fixed height. The air is discharged at both ends along the row of seats. Do not interfere with the back of chair seats when they are raised. Made of heavy cast iron with heavy wire screens locked into grooves at each end. Damper easily adjusted with screwdriver.

Size *No.	Dimensions, Inches			Area, Sq. Ft.	C.f.m. at 300 Velocity
	High	Wide	Long		
2	2⅛	8½	4½	0.223	67
3	3⅛	8½	6½	0.333	100
4	4⅛	8½	8½	0.45	134
5	5⅛	8½	10½	0.56	167
6	6⅛	8½	12½	0.67	200

*With or without regulating damper.





Standard Aisle Hood Air Deflectors are used to throw the fresh air out into the aisles in one direction. They provide the engineer with an inexpensive method of introducing a large volume of air wherever needed without causing annoying drafts. A curved damper reduces friction loss.

	Long	Wide	High	Lbs.	C. F. M. at 300 Vel.	Area Sq. Ft.
Small Size.....	8″	4½″	4½″	9½	75	0.25
Large Size.....	8″	6″	6″	13	100	0.333

May also be made in any size to suit conditions.

Send for NEW BOOKLET *of Complete Engineering Data*

General Air Filters Corporation

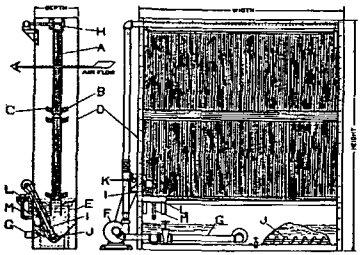
Division, The W. B. Connor Co., Inc.

367D Lexington Avenue :-: **New York City**

PRODUCTS—Manufacturers of Air Purification and Conditioning Equipment, Air Filters, Air Washers, Spray Nozzles; Steam Traps; Pumps for All Viscous Liquids.

Ace Full Automatic, Self-cleaning Air Filter

Types and Sizes for All Applications where clean air is needed for general ventilating, the protection and preservation of motors, generators, compressors and other machinery, and for food products and other materials in process of manufacture and in stock.

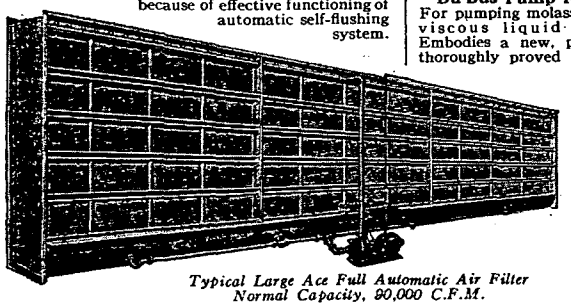


A—Filter Cell. B—Front Flashing, removable. C—Combined Rear Flashing and Cell Support. D—Steel End Framing. E—Reservoir. F—Flush Pump Unit. G—Pump Suction from Reservoir. H—Flushing Liquid Distributor. I—Bucket Sediment Conveyor. J—Spiral Sediment Conveyor. K—Drive for Sediment Ejector Mechanism. L—Cloth Strainer Basket. M—Return Oil Drain from Strainer Basket.

Normal capacity, individual cells, 5500 c.f.m. For any capacity, length of filter equals 2 ft. by necessary number of sections; height equals 40½ in. by number of cells, plus 27 in. for reservoir at bottom and oil distributor at top. Depth, all filters, 21½ in. Resistance, .26-in. water gauge.

Requires No Attention in Service.—Cleans the air thoroughly, washes itself and ejects the accumulated sediment automatically.

Air-Cleaning Efficiency.—As near 100 per cent as can be attained by any practical air-cleaning device. This is due to the patented two-stage filter media. Initial high efficiency and low resistance to air flow are maintained in service because of effective functioning of automatic self-flushing system.



Typical Large Ace Full Automatic Air Filter Normal Capacity, 90,000 C.F.M.

Requires Minimum Floor Space.—Can be erected in "L" or "U" formations where space is limited.

Ace Eliminates All Manual Cleaning.—It is simple, positive, durable, safe, with minimum erection, operating and maintenance costs.

Ace Automatic for Continuous Duty.—This type flushes itself while air is passing through. Used where continuous uninterrupted service is imperative.

Ace Hand-Cleaned (Unit Type) Air Filter

Built up of easily removable unit cells. Cells are washed by hand. Spare cells are substituted for those being cleaned, making interruption to service negligible. This type is fully equal to the automatic in air-cleaning efficiency, and is admirably suited for all applications where small filters are adequate, and for large installations where proper attendance is practicable.

Engineering and Laboratory Service.—Full co-operation offered for working out individual and special air-cleaning problems.

Ace Non-Return Steam Trap (With the Improved Corliss Valve)

Has only five parts. No screws, pins, toggles, springs, packing or stuffing boxes—nothing to come loose or get out of order. No adjustments. Cannot clog or air-bind. Steamtight and water-sealed, self-cleaning Corliss valve. Large drainage capacity, hair-trigger sensitiveness. Shipped ready for easy installation.

Shortt Pumping Trap.—*For pumping* high and low temperature fluids such as gasoline, oil, acids, condensates. *For draining* condensers, dry kilns, blast coils, vacuum pans, water heaters, receivers, paper machine dryers, etc. *For feeding* boilers. Has high capacity and efficiency. Stationary receiver design eliminates trunnions, dashpots, bumpers and balance weights. Piston operation of pressure and vent valves gives quick, full opening action. All valves and operating mechanism outside; nothing inside but the float. Cannot air-bind; requires no adjustment. Easy to install; absolutely reliable. Works equally well on steam or air.

Du Bus Pump for All Viscous Liquids.—For pumping molasses, oils, tar products and any viscous liquid that will pass through pipes. Embodies a new, patented mechanical principle thoroughly proved in service. Gives higher capacities with much lower power requirements and slow operating speed; smooth, balanced rotary action; uniform discharge, air-free and at uniform pressure. Has only three moving parts. Simple, powerful, thoroughly reliable. Small space requirements. Low operating and maintenance costs.

Literature and Quotations.—Information on any of these products sent on request.

MIDWEST AIR FILTERS

INCORPORATED

BRADFORD **PENNSYLVANIA**

Midwest Canada, Ltd. **Montreal, Canada**

Branches in Principal Cities

Horizontal Self-Cleaning Filter

The Midwest Horizontal Filter consists of interchangeable unit cells laid horizontally in tiers, with diagonal baffle aprons for pre-cleaning air of heavy dust placed between. Cleaning is accomplished by an automatic flushing device which travels back and forth over the cells, flushing one row at a time, with oil traveling in direction of fine to coarse filter medium, against air flow. Push button or automatic control is furnished.

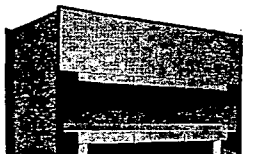
Over 40 gal. of Viscosine are used per cell per cleaning. There are over 19,000 sq. in. of filter medium in each cell operating at low resistance. Cleaning of filter can be accomplished without shutting down fans when desirable. Fans can be slowed down and c.f.m. reduced without affecting the efficiency of this filter. Power consumption is low, less than ½ hp. being capable of cleaning more than 1,500,000 sq. in. of impingement surface. Efficiency 97-99 per cent guaranteed. Pressure drop, ⅜ in. water gauge, constant. Capacity 3,000 c.f.m. and up. Viscosine consumption, 1 gal. per 1,000 c.f.m.—a year's supply.



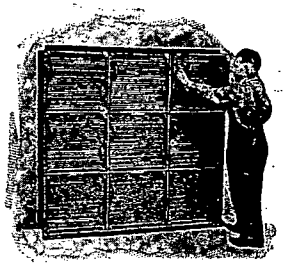
Section of Clean Cell



Section of Cell after being put in operation



A Nine-Cell Horizontal Filter



A Nine-Cell Unit Filter

Construction

All types of Midwest Filters are based upon the unit principle of construction, each cell being a complete and interchangeable unit. The filter cell proper consists of a heavy, welded box-like frame with expanded metal front and back, containing a series of strong, specially shaped filter sheets, so arranged as to provide progressively increasing density from front to rear of the cell. Note in the illustration how dust accumulates but does not obstruct.

Midwest Unit Filters

Unit installations are built in wall type set-ups to deliver the required air capacity, and are assembled in angle iron frames to fit the space available. Midwest cells are easiest to install and handle. They automatically snap into place and require no corner clips. Rigid one-piece frames provide durable, leak-proof joints. Filter medium of progressively increasing density provides maximum dust holding capacity. Filter area is 19 per cent larger than in other styles of filter unit, making for low resistance and efficiency of 97 to 99 per cent guaranteed. Can be cleaned by steam or hot water hose. Complete recommendations, drawings and data furnished without charge.

National Air Filter Company

Manufacturers of Air Filters

5130 Ravenswood Avenue, **Chicago**

Products:

National Air Filters—Dry types, manually serviced and automatic; oil coated types, fully automatic, semi-automatic, and manually operated.

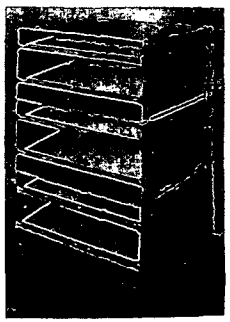
A National Filter for Every Need:

Beginning with the Phoenix Filter, the standard self-cleaning air filter and the only one in its class having a long record of successful operation, the National line has been developed to include types specially adapted for all the conditions encountered in ventilating and industrial installations.

The two most widely applicable models are the AIRMAT and the TooPas.

The AIRMAT Filter:

The AIRMAT—unique in its utilization of a dry fibrous textured filtering medium—presents a high standard of efficiency and a simple economical method of servicing, heretofore unknown among air filters.



The specially developed filtering mat sold under the trade name "AIRMAT" comprises multiple layers each with millions of tiny openings which permit the air to pass with little resistance, but cause it to leave behind all dirt particles in the mases of the mat.

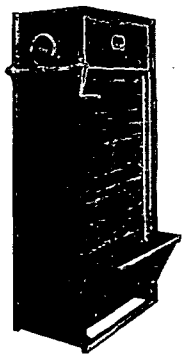
In the AIRMAT sectional filter, sheets of this filtering medium 2 ft. square are held by wire frames in sectional cabinets 12 in. high, 24 in. wide and 24 in. deep. Each of these sections holds 4 AIRMAT frames and has a filtering capacity of 1000 c.f.m. Any desired capacity can be secured by laying up these sections in tiers like filing cabinets.

The servicing of this filter is simple, easy and clean. The mats are used for a predetermined length of time, depending on the amount of dirt in the air and the degree of efficiency desired. When a mat is soiled, the frame is removed from the cabinet, the mat taken out and thrown away, and a clean one inserted. The cost of AIRMAT replacements constitutes the lowest material cost of any manually serviced system of air filtration. But the big saving is in labor. With the AIRMAT, this is practically nothing.

Architects can take advantage of any space available for this filter because of its sectional construction. Additions or changes are obviously easy to make. There are no accessories to an AIRMAT installation. No space is required for tanks or other special equipment.

The TooPas Filter:

The TooPas, like the time tested Phoenix, embodies the double pass principle of cleaning the air. The filtering medium is an endless curtain composed of multiple layers of woven copper ribbon and coarser outer layers of expanded metal. This is made up in small units flexibly connected which operate over supporting wheels in the form of a roller curtain. The lower end of this curtain dips into a tank of oil which removes the dirt from the filtering medium by solvent action. Years of experience with the Phoenix Filter have demonstrated that this is the most simple and satisfactory means for removing dirt from a metal surface. In this system, there is no need to pump the oil. Pumps with all of their troubles are eliminated. The oil never has to be removed or treated. Since it is never disturbed, it clarifies itself by the natural process of sedimentation.



The TooPas Filter is easy to operate by a simple hand crank. Several sections can be placed side by side and operated by a single handle. Servicing is limited to a few turns each week. When motor drive is advisable, it can be furnished at nominal extra cost.

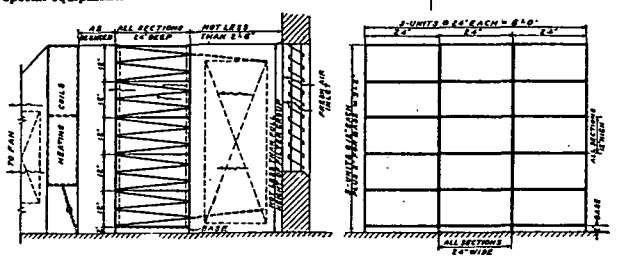
The important advantages of this filter are:

1. The elimination of oil entrainment. The double pass principle makes it possible to absolutely guarantee this filter against oil entrainment in the air.

2. Unit construction of standard width and any required height. This permits the ready adaptability of this filter to any ventilation system—office building, school, hospital, theater, church, public building or factory.

3. Adaptability to volume manufacture, ease of shipping and erecting. This filter for the first time brings the advantages of the Phoenix principle into a form which lends itself to volume production. All parts are carried in stock and assembly can be made on short notice. The sheet metal duct work is readily attached to the frame work of the sections. No other framing is necessary. The contractor saves in labor and has very little to figure on in the erection of the TooPas. Note the table of sizes and capacities.

Size number	Rated capacity c.f.m.	Net weight 1 section incl. oil	Shipping weight	Dim. A over-all height	Dim. B height of opening
48	4,000	750	1030	6'-4"	4'-0"
60	5,000	800	1100	7'-4"	5'-0"
72	6,000	850	1170	8'-4"	6'-0"
84	7,000	900	1240	9'-4"	7'-0"
96	8,000	950	1310	10'-4"	8'-0"
108	9,000	1000	1380	11'-4"	9'-0"
120	10,000	1050	1450	12'-4"	10'-0"



Application of AIRMAT Filter, showing Cross Section, Elevation, and Front View

Other Types:

In addition to the two types described above, the National line of oil coated filters includes the Phoenix constant effect filter, the Rotary self-cleaning filter, the Simplex, and the Cartridge Compressor Filter. It also includes several styles of Dust Arresters and the Dri-Drum, using "AIRMAT," the dry filtering medium. This company's engineers have had many years of specialized experience in connection with air filtration and will gladly counsel with you regarding any special applications.

Reed Air Filter Co., *Incorporated*

Factory and General Offices:

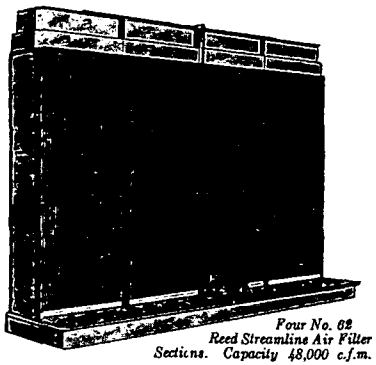
202 Central Avenue, **Louisville, Ky.**

District Representatives in Principal Cities

Reed Air Filters

Reed Air Filters—Streamline Self-Cleaning, Continuous and Standard Unit Types—provide a simple, efficient, economical method of supplying clean air for general ventilation purposes and industrial processes.

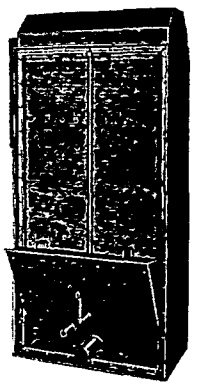
Reed Streamline Automatic Air Filter—The Reed Streamline (Self-Cleaning) Filter is an outstanding development in automatic air filtration. It is entirely automatic and requires no personal attention in its operation. The filtering media, consisting of staggered rows of streamline baffles similar to the low-wind-resistance shapes developed in airplane service, is stationary, thus eliminating moving parts. These forms offer less resistance to air flow than any other shape yet developed. Performance characteristics are constant, cleaning efficiency guaranteed 97 per cent, resistance to air flow 0.25 in. of water.



Four No. 62 Reed Streamline Air Filter Sections. Capacity 48,000 c.f.m.

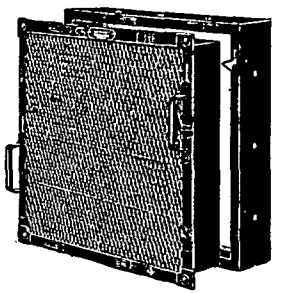
To facilitate the laying out and installation of filters of various capacities, and to best use whatever space is available, the Reed Streamline is built in standard sections, in three different sizes and capacities. Complete half sections are made to furnish intermediate capacities between multiples of the standard sections. Instead of the usual Reed Automatic Electric Control, a push button control or time switch may be installed when the fan is operated intermittently.

Reed Continuous Filter—The Reed Continuous Filter has been developed for the exacting air-cleaning requirements and severe operating conditions for such applications as turbo-generators, mill motors, Diesel engines, air compressors and manufacturing processes that demand continuous operation with maximum efficiency in dust removal. While conventional in appearance, it embodies several new principles in automatic air filtration. Its efficiency in dust removal is comparable to the Type A Reed Unit Filter which has the highest efficiency of any air filter on the market. Made in various types and sizes.



The Reed Continuous Air Filter—For Heavy-Duty, Uninterrupted Service

Reed Standard Unit Air Filter—The Reed Standard Unit Air Filter consists of a durable metal cell progressively packed with double-crimped, galvanized wire filtering media thoroughly coated with Adhesine. Because of the small size of the individual baffles, this form of media separates the air into innumerable fine streams, insures the greatest number of impingements and makes possible the highest cleaning efficiency—97 to 99 per cent guaranteed.



A Reed Air Filter Unit

By progressively packing the media and gradually increasing the density toward the rear of the filter, greater dust capacity and minimum increase in resistance are assured. Periods between cleanings are therefore correspondingly increased. The Reed Automatic Latch facilitates the handling of cells in restricted areas and the felt gasket between cell and frame prevents leakage and insures full efficiency.

The new Reed Steam Cleaning Tank cleans the cells far more thoroughly and the labor of manual washing is entirely eliminated. Our engineering department will gladly furnish complete data and drawings on any Reed Air Filter, for any purpose, without cost or obligation.

Whiting Corporation

HARRINGTON STOKER DIVISION

Harvey, Illinois

Manufacturers of the "King Coal" Automatic Stoker for Heating and Small Power Plant Boilers

The "King Coal" Automatic Stoker is a front, over-feed, stepped grate mechanism having two stationary and two movable sections wherein gravity plays no part in progression of the fuel bed. It provides fully automatic stoking of boilers from 40 hp. and up.

Hospitals, hotels, apartments, schools and laundries find its smokeless combustion, fuel saving and fully automatic features of substantial value in figuring their heating costs.

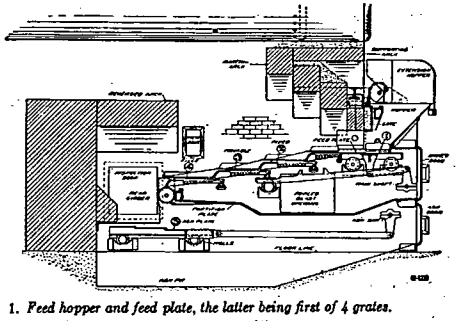
Standardization—All sizes of "King Coal" Automatic Stokers are identical in construction. Adding sections to length and additional width increases the capacity. Each section or step is made up of individual grate bars which merely rest in place (no multiplicity of pins, cotters, bolts or joints).

Flexibility—Varying speed of travel and depth of coal bed secured by a one to four inch adjustability of the stroke and the adjustability of the hopper gate. Only alternate grates are movable, thus securing uniform flow of coal without caking.

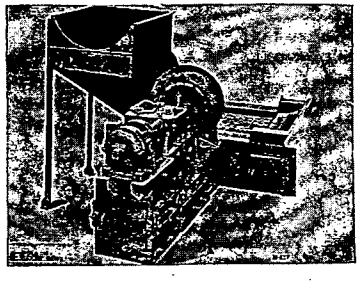
Fuel—Coal of the cheapest grade is burned at high efficiency.

Forced Draft—This takes care of low chimney troubles in small boiler installations.

Ash Discharge—Stokers are entirely self-cleaning and the patent ash discharge provides a continuous ash seal where all of the latent heat in the ash is given up before being discharged into the pit.



1. *Feed hopper and feed plate, the latter being first of 4 grates.*
2. *Second grate section rests upon grate (5).*
3. *Movable grate section rests and slides upon (4), at the same time sliding back and forth under section (2).*
4. *Rear grate.*
5. *Ash plate.*



Standard Sizes

Grate Widths (in feet)..... 3, 4, 5, 6
Grate Lengths (effective grate surface, in feet), 6, 7, 8, 9
Each width can be made in either length. Required furnace width always just one foot more than the grate width. Furnace depth for 6-ft. stoker is 7 ft. 5 in.; furnace depth for 8 and 9-ft. stoker is 10 ft. 2 in.

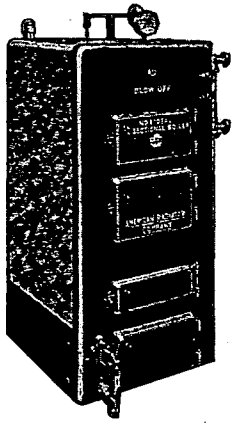
"King Coal" Model "B" Stoker

Designed particularly for simple and easy installation in boilers of the fire box type as well as the smaller brickset boilers. Range in coal burning capacity from 40 to 500 pounds of coal per hour. Smokeless combustion guaranteed, and self-cleaning fires.

AMERICAN RADIATOR COMPANY

40 West 40th Street, **New York City**

Manufacturers of Ideal Redflash Boilers, American Corto Radiators and other Products for Heating, Ventilating and Refrigerating



IDEAL REDFLASH BOILERS

for Hard Coal, Soft Coal, Coke, Oil, and Gas

1—Perfected Design—Highly Efficient—The Ideal Redflash Boiler has a very rapid pick-up capacity.

2—Thoroughly and Indestructibly Insulated.

3—Completely Equipped with Automatic Regulation and All Accessories.

4—Permanently Beautiful.
All Doors Porcelain Enameled.

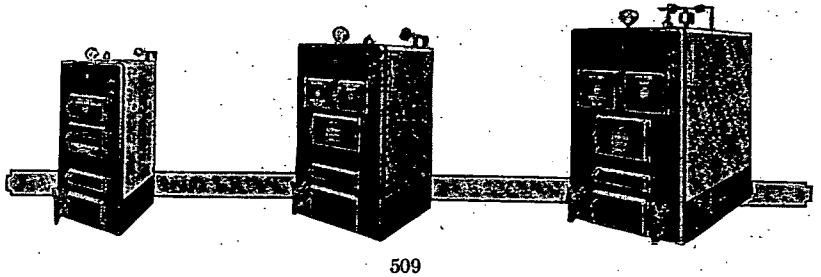
The New Ideal Redflash Boiler is the achievement of forty years of designing and manufacturing experience. Its perfected sectional design insures quick heating response and a high degree of operating economy.

The boiler is completely equipped, both water and steam, with automatic regulation and all accessories. It is thoroughly and indestructibly insulated. Its cleanliness and beauty permit the use of the basement as a livable place.

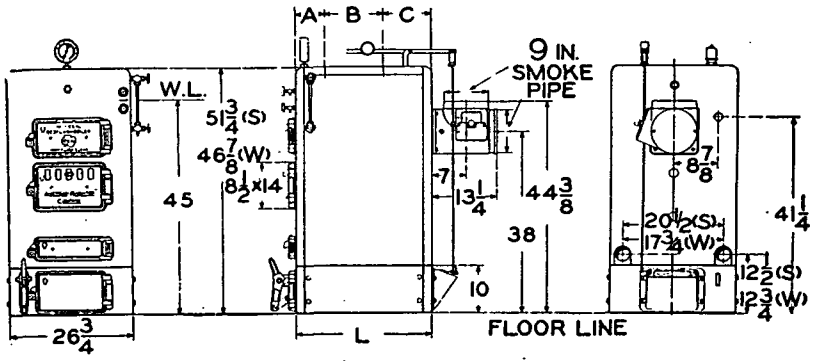
The Ideal Redflash Boiler (sizes 2, 3, 4 and 5) are available also with the famous Ideal Smoke Oxidizer for the burning of any grade of soft coal. This simple, perfected device is water-backed throughout, and cannot burn out.

The Ideal Redflash Boiler for soft coal does not require any special degree of skilled attendance. It is easily fired and cared for, assuring satisfactory service with ordinary attention.

A catalog containing complete data on these boilers will gladly be sent on request.



Data and Measurements
NO. 1 IDEAL REDFLASH BOILER
Burns Hard and Soft Coal, Coke, Oil, and Gas

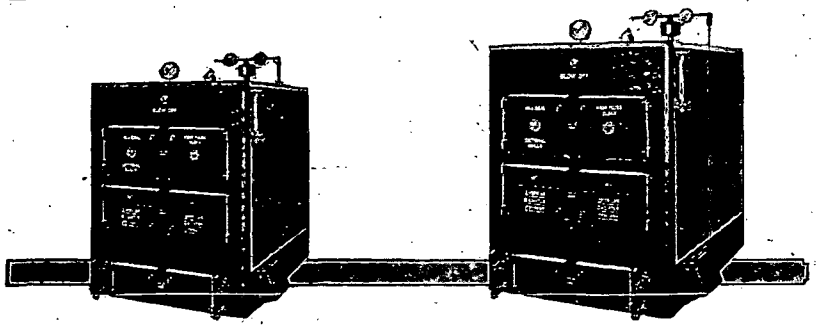


STEAM

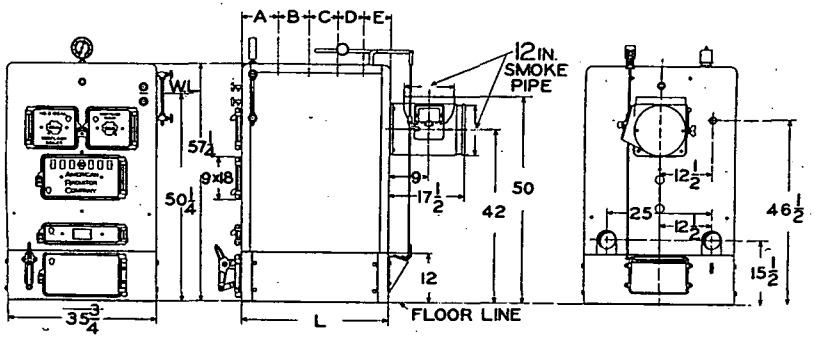
Number of Boiler	Rating Steam Sq. Ft.	Grate Area Sq. Ft.	Fuel Capacity Lbs.	Outlets No. and Size	Inlets No. and Size	Chimney		Dimensions—Inches For Locating Flow Tappings			
						Size Inches	Height Feet	A	B	C	L
1-S-4	350	1.33	120	1-3″	2-2″	8 x 8	30	11½	....	4½	16
1-S-5	500	1.79	160	1-3″	2-2″	8 x 8	30	15½	....	4½	20
1-S-6	650	2.25	200	2-3″	2-2″	8 x 8	30	12	7½	4½	24
1-S-7	800	2.71	240	2-3″	2-2″	8 x 12	35	8	15½	4½	28
1-S-8	950	3.17	280	2-3″	2-2″	8 x 12	35	12	15½	4½	32
1-S-9	1100	3.63	320	2-3″	2-2″	8 x 12	35	16	15½	4½	36

WATER

Number of Boiler	Rating Water Sq. Ft.	Grate Area Sq. Ft.	Fuel Capacity Lbs.	Outlets No. and Size	Inlets No. and Size	Chimney		Dimensions—Inches For Locating Flow Tappings			
						Size Inches	Height Feet	A	B	C	L
1-W-4	600	1.33	120	1-3″	2-3″	8 x 8	30	11½	....	4½	16
1-W-5	850	1.79	160	1-3″	2-3″	8 x 8	30	15½	....	4½	20
1-W-6	1100	2.25	200	2-3″	2-3″	8 x 8	30	12	7½	4½	24
1-W-7	1350	2.71	240	2-3″	2-3″	8 x 12	35	8	15½	4½	28
1-W-8	1600	3.17	280	2-3″	2-3″	8 x 12	35	12	15½	4½	32
1-W-9	1850	3.63	320	2-3″	2-3″	8 x 12	35	16	15½	4½	36



Data and Measurements
NO. 2 IDEAL REDFLASH BOILERS
Burns Hard Coal, Coke, Oil, and Gas
Smokeless Type burns Soft Coal Smokelessly



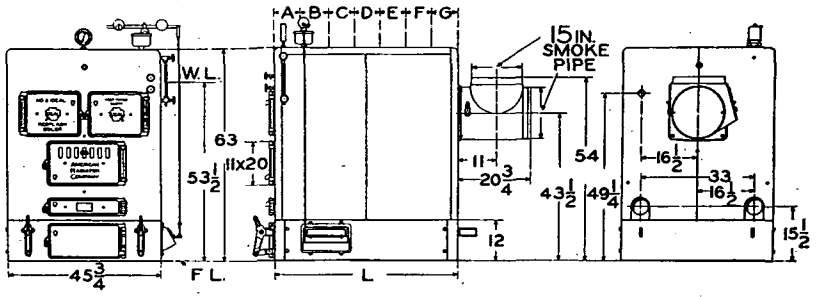
STEAM

Number of Boiler	Rating Steam Sq. Ft.	Number of Boiler (Smokeless)	Rating Steam Sq. Ft.	Grate Area Sq. Ft.	Fuel Capacity Lbs. Anthracite Only	Outlets No. and Size	Inlets No. and Size	Chimney		Dimensions—Inches For Locating Flow Tappings					
								Size Inches	Height Feet	A	B	C	D	E	L
2-S-5	1,050	.....	.....	3.50	320	2-3½″	2-4″	8 x 12	35	10	10	..	..	5	25
2-S-6	1,300	.....	.....	4.39	400	2-3½″	2-4″	12 x 12	35	15	10	..	..	5	30
2-S-7	1,550	.....	.....	5.28	480	2-3½″	2-4″	12 x 12	35	10	20	..	..	5	35
2-S-8	1,800	2-S-8-S	1,800	6.17	560	2-3½″	2-4″	12 x 12	40	15	20	..	..	5	40
2-S-9	2,050	2-S-9-S	2,050	7.06	640	2-3½″	2-4″	12 x 16	40	30	30	..	..	5	45
2-S-10	2,300	2-S-10-S	2,300	7.95	720	2-3½″	2-4″	12 x 16	45	15	30	..	..	5	50
2-S-11	2,550	2-S-11-S	2,550	8.84	800	3-3½″	2-4″	12 x 16	45	10	20	20	..	5	55
.....	.....	2-S-12-S	2,800	9.73	...	3-3½″	2-4″	12 x 16	50	15	30	10	..	5	60
.....	.....	2-S-13-S	3,050	10.62	...	4-3½″	2-4″	12 x 16	50	20	10	20	10	5	65

WATER

Number of Boiler	Rating Water Sq. Ft.	Number of Boiler (Smokeless)	Rating Water Sq. Ft.	Grate Area Sq. Ft.	Fuel Capacity Lbs. Anthracite Only	Outlets No. and Size	Inlets No. and Size	Chimney		Dimensions—Inches For Locating Flow Tappings					
								Size Inches	Height Feet	A	B	C	D	E	L
2-W-5	1,800	.....	.....	3.50	320	2-3½″	2-4″	8 x 12	35	10	10	..	..	5	25
2-W-6	2,200	.....	.....	4.39	400	2-3½″	2-4″	12 x 12	35	15	10	..	..	5	30
2-W-7	2,600	.....	.....	5.28	480	2-3½″	2-4″	12 x 12	35	10	20	..	..	5	35
2-W-8	3,000	2-W-8-S	3,000	6.17	560	2-3½″	2-4″	12 x 12	40	15	20	..	..	5	40
2-W-9	3,400	2-W-9-S	3,400	7.06	640	2-3½″	2-4″	12 x 16	40	30	30	..	..	5	45
2-W-10	3,800	2-W-10-S	3,800	7.95	720	2-3½″	2-4″	12 x 16	45	15	30	..	..	5	50
2-W-11	4,200	2-W-11-S	4,300	8.84	800	3-3½″	2-4″	12 x 16	45	10	20	20	..	5	55
.....	.....	2-W-12-S	4,600	9.73	...	3-3½″	2-4″	12 x 16	50	15	30	10	..	5	60
.....	.....	2-W-13-S	5,000	10.62	...	4-3½″	2-4″	12 x 16	50	20	10	20	10	5	65

Data and Measurements
NO. 3 IDEAL REDFLASH BOILER
Burns Hard Coal, Coke, Oil, and Gas
Smokeless Type burns Soft Coal Smokelessly



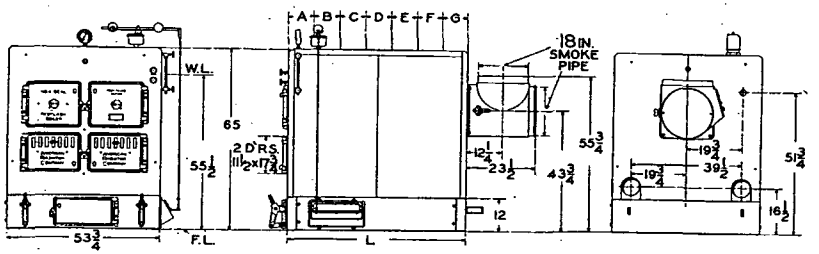
STEAM

Number of Boiler	Rating Steam Sq. Ft.	Number of Boiler (Smokeless)	Rating Steam Sq. Ft.	Grate Area Sq. Ft.	Fuel Capacity Lbs. Anthracite Only	Outlets No. and Size	Inlets No. and Size	Chimneys		Dimensions—Inches For Locating Flow Tappings							
								Size Inches	Height Feet	A	B	C	D	E	F	G	L
3-S-6	2,500	.....	.....	6.65	590	2–3½″	2–5″	12 x 16	40	9	18	..	..	..	..	9	36
3-S-7	3,000	.....	.....	8.00	710	3–3½″	2–5″	16 x 16	45	9	12	12	..	..	..	9	42
3-S-8	3,500	3-S-8-S	3,500	9.35	830	3–3½″	2–5″	16 x 16	50	9	18	12	..	..	..	9	48
3-S-9	4,000	3-S-9-S	4,000	10.70	950	4–3½″	2–5″	16 x 20	50	9	12	12	12	..	..	9	54
3-S-10	4,500	3-S-10-S	4,500	12.05	1,070	4–3½″	2–5″	16 x 20	55	9	12	12	12	..	..	15	60
3-S-11	5,000	3-S-11-S	5,000	13.40	1,190	4–3½″	2–5″	20 x 20	60	9	12	18	18	..	..	9	66
3-S-12	5,500	3-S-12-S	5,500	14.75	1,310	5–3½″	2–5″	20 x 20	65	9	18	12	12	12	..	9	72
3-S-13	6,000	3-S-13-S	6,000	16.10	1,430	5–3½″	2–5″	20 x 20	65	9	18	18	12	12	..	9	78
.....	.....	3-S-14-S	6,500	17.45	.....	6–3½″	2–5″	20 x 20	70	9	12	12	18	12	12	9	84

WATER

Number of Boiler	Rating Water Sq. Ft.	Number of Boiler (Smokeless)	Rating Water Sq. Ft.	Grate Area Sq. Ft.	Fuel Capacity Lbs. Anthracite Only	Outlets No. and Size	Inlets No. and Size	Chimneys		Dimensions—Inches For Locating Flow Tappings							
								Size Inches	Height Feet	A	B	C	D	E	F	G	L
3-W-6	4,200	.....	.....	6.65	590	2–3½″	2–5″	12 x 16	40	9	18	..	..	..	..	9	36
3-W-7	5,000	.....	.....	8.00	710	3–3½″	2–5″	16 x 16	45	9	12	12	..	..	..	9	42
3-W-8	5,800	3-W-8-S	5,800	9.35	830	3–3½″	2–5″	16 x 16	50	9	18	12	..	..	..	9	48
3-W-9	6,600	3-W-9-S	6,600	10.70	950	4–3½″	2–5″	16 x 20	50	9	12	12	12	..	..	9	54
3-W-10	7,400	3-W-10-S	7,400	12.05	1,070	4–3½″	2–5″	16 x 20	55	9	12	12	12	..	..	15	60
3-W-11	8,200	3-W-11-S	8,200	13.40	1,190	4–3½″	2–5″	20 x 20	60	9	12	18	18	..	..	9	66
3-W-12	9,000	3-W-12-S	9,000	14.75	1,310	5–3½″	2–5″	20 x 20	65	9	18	12	12	12	..	9	72
3-W-13	9,800	3-W-13-S	9,800	16.10	1,430	5–3½″	2–5″	20 x 20	65	9	18	18	12	12	..	9	78
.....	.....	3-W-14-S	10,600	17.45	.....	6–3½″	2–5″	20 x 20	70	9	12	12	18	12	12	9	84

Data and Measurements
NO. 4 IDEAL REDFLASH BOILER
Burns Hard Coal, Coke, Oil, and Gas
Smokeless Type burns Soft Coal Smokelessly



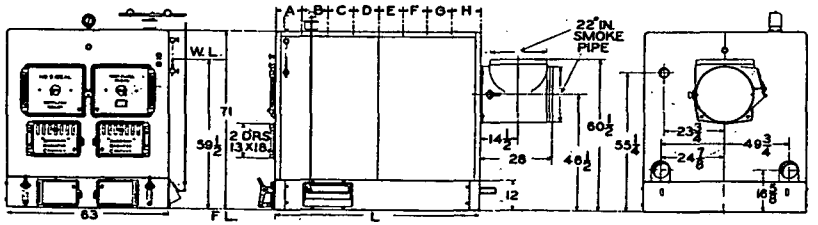
STEAM

Number of Boiler	Rating Steam Sq. Ft.	Number of Boiler (Smokeless)	Rating Steam Sq. Ft.	Grate Area Sq. Ft.	Fuel Capacity Lbs. Anthracite Only	Outlets No. and Size	Inlets No. and Size	Chimneys		Dimensions—Inches For Locating Flow Tappings							
								Size Inches	Height Feet	A	B	C	D	E	F	G	L
4-S-7	5,000	.....	.....	11.70	950	3–4″	2–6″	16 x 20	50	10½	14	14	..	..	..	10½	49
4-S-8	5,750	.....	.....	13.68	1,110	3–4″	2–6″	20 x 20	55	10½	14	14	..	..	..	17½	56
4-S-9	6,500	4-S-9-S	6,500	15.66	1,270	4–4″	2–6″	20 x 20	55	10½	14	14	14	..	..	10½	63
4-S-10	7,250	4-S-10S	7,250	17.64	1,430	4–4″	2–6″	20 x 20	60	10½	14	14	14	..	..	17½	70
4-S-11	8,000	4-S-11S	8,000	19.62	1,590	5–4″	2–6″	20 x 24	65	10½	14	14	14	14	..	10½	77
4-S-12	8,750	4-S-12-S	8,750	21.60	1,750	5–4″	2–6″	20 x 24	70	10½	14	14	14	14	..	17½	84
4-S-13	9,500	4-S-13-S	9,500	23.58	1,910	6–4″	2–6″	20 x 24	75	10½	14	14	14	14	14	10½	91
.....	.....	4-S-14-S	10,250	25.56	.....	6–4″	2–6″	20 x 24	75	10½	14	14	14	14	14	17½	98

WATER

Number of Boiler	Rating Water Sq. Ft.	Number of Boiler (Smokeless)	Rating Water Sq. Ft.	Grate Area Sq. Ft.	Fuel Capacity Lbs. Anthracite Only	Outlets No. and Size	Inlets No. and Size	Chimneys		Dimensions—Inches For Locating Flow Tappings							
								Size Inches	Height Feet	A	B	C	D	E	F	G	L
4-W-7	8,500	.....	.....	11.70	950	3–4″	2–6″	16 x 20	50	10½	14	14	..	..	..	10½	49
4-W-8	9,750	.....	.....	13.68	1,110	3–4″	2–6″	20 x 20	55	10½	14	14	..	..	..	17½	56
4-W-9	11,000	4-W-9-S	11,000	15.66	1,270	4–4″	2–6″	20 x 20	55	10½	14	14	14	..	..	10½	63
4-W-10	12,250	4-W-10-S	12,250	17.64	1,430	4–4″	2–6″	20 x 20	60	10½	14	14	14	..	..	17½	70
4-W-11	13,500	4-W-11-S	13,500	19.62	1,590	5–4″	2–6″	20 x 24	65	10½	14	14	14	14	..	10½	77
4-W-12	14,750	4-W-12-S	14,750	21.60	1,750	5–4″	2–6″	20 x 24	70	10½	14	14	14	14	..	17½	84
4-W-13	16,000	4-W-13-S	16,000	23.58	1,910	6–4″	2–6″	20 x 24	75	10½	14	14	14	14	14	10½	91
.....	.....	4-W-14-S	17,250	25.56	.....	6–4″	2–6″	20 x 24	75	10½	14	14	14	14	14	17½	98

Data and Measurements
NO. 5 IDEAL REDFLASH BOILER
Burns Hard Coal, Coke, Oil, and Gas
Smokeless Type burns Soft Coal Smokelessly



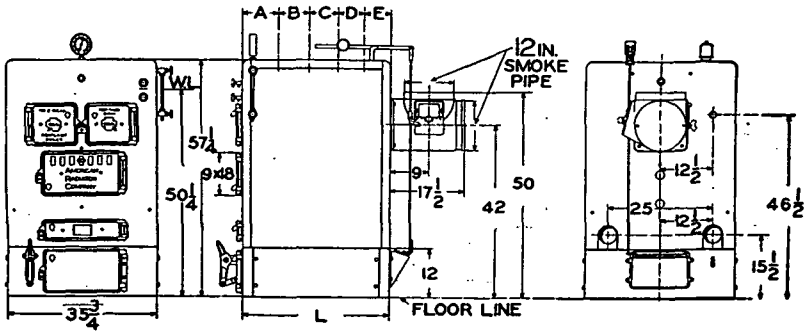
STEAM

Number of Boiler	Rating Steam Sq. Ft.	Number of Boiler (Smokeless)	Rating Steam Sq. Ft.	Grate Area Sq. Ft.	Fuel Capacity Lbs.	Outlets No. and Size	Inlets No. and Size	Chimneys		Dimensions—Inches For Locating Flow Tappings								
								Size Inches	Height Feet	A	B	C	D	E	F	G	H	L
5-S-8	8,000	.....	.....	18.83	1,281	3–5″	2–6″	24 x 28	70	12	24	16	..	..	..	..	12	64
5-S-9	9,100	5-S-9-S	9,100	21.52	1,464	4–5″	2–6″	24 x 28	75	12	16	16	16	..	..	..	12	72
5-S-10	10,200	5-S-10-S	10,200	24.21	1,647	4–5″	2–6″	24 x 28	75	12	16	24	16	..	..	..	12	80
5-S-11	11,300	5-S-11-S	11,300	26.90	1,830	5″5″	2–6″	24 x 28	80	12	16	16	16	16	..	..	12	88
5-S-12	12,400	5-S-12-S	12,400	21.52	1,464	5–5″	2–6″	24 x 28	85	12	16	16	16	16	..	..	20	96
5-S-13	13,500	5-S-13-S	13,500	24.21	1,647	5–5″	2–6″	30 x 36	85	12	16	24	16	24	..	..	12	104
5-S-14	14,600	5-S-14-S	14,600	24.21	1,647	6–5″	2–6″	30 x 36	90	12	16	16	24	16	16	..	12	112
5-S-15	15,700	5-S-15-S	15,700	26.90	1,830	6–5″	2–6″	30 x 36	95	12	16	24	16	24	16	..	12	120
5-S-16	16,800	5-S-16-S	16,800	26.90	1,830	7–5″	2–6″	30 x 36	100	12	16	16	16	16	16	16	20	128
5-S-17	17,900	5-S-17-S	17,900	26.90	1,830	7–5″	2–6″	30 x 36	105	12	16	24	16	24	16	16	12	136

WATER

Number of Boiler	Rating Water Sq. Ft.	Number of Boiler (Smokeless)	Rating Water Sq. Ft.	Grate Area Sq. Ft.	Fuel Capacity Lbs.	Outlets No. and Size	Inlets No. and Size	Chimneys		Dimensions—Inches For Locating Flow Tappings								
								Size Inches	Height Feet	A	B	C	D	E	F	G	H	L
5-W-8	13,200	.....	.....	18.83	1,281	3–5″	2–6″	24 x 28	70	12	24	16	..	..	..	..	12	64
5-W-9	15,000	5-W-9-S	15,000	21.52	1,464	4–5″	2–6″	24 x 28	75	12	16	16	16	..	..	..	12	72
5-W-10	16,800	5-W-10-S	16,800	24.21	1,647	4–5″	2–6″	24 x 28	75	12	16	24	16	..	..	..	12	80
5-W-11	18,600	5-W-11-S	18,600	26.90	1,830	5–5″	2–6″	24 x 28	80	12	16	16	16	16	..	..	12	88
5-W-12	20,400	5-W-12-S	20,400	21.52	1,464	5–5″	2–6″	24 x 28	85	12	16	16	16	16	..	..	20	96
5-W-13	22,200	5-W-13-S	22,200	24.21	1,647	5–5″	2–6″	30 x 36	85	12	16	24	16	24	..	..	12	104
5-W-14	24,000	5-W-14-S	24,000	24.21	1,647	6–5″	2–6″	30 x 36	90	12	16	16	24	16	16	..	12	112
5-W-15	25,800	5-W-15-S	25,800	26.90	1,830	6–5″	2–6″	30 x 36	95	12	16	24	16	24	16	..	12	120
5-W-16	27,600	5-W-16-S	27,600	26.90	1,830	7–5″	2–6″	30 x 36	100	12	16	16	16	16	16	16	20	128
5-W-17	29,400	5-W-17-S	29,400	26.90	1,830	7–5″	2–6″	30 x 36	105	12	16	24	16	24	16	16	12	136

Data and Measurements
NO. 2 IDEAL REDFLASH SMOKELESS BOILER
Burns All Grades of Soft Coal Smokelessly



SMOKELESS—STEAM

Number of Boiler	Rating Steam Sq. Ft.	Grate Area Sq. Ft.	Outlets No. and Size	Inlets No. and Size	Chimney		Dimensions—Inches For Locating Flow Tappings					
					Size Inches	Height Feet	A	B	C	D	E	L
2-S-8-S	1,800	6.17	2-3½″	2-4″	12 x 12	40	15	20	..	..	5	40
2-S-9-S	2,050	7.06	2-3½″	2-4″	12 x 16	40	20	20	..	..	5	45
2-S-10-S	2,300	7.95	2-3½″	2-4″	12 x 16	45	15	30	..	..	5	50
2-S-11-S	2,550	8.84	3-3½″	2-4″	12 x 16	45	10	20	20	..	5	55
2-S-12-S	2,800	9.73	3-3½″	2-4″	12 x 16	50	15	30	10	..	5	60
2-S-13-S	3,050	10.62	4-3½″	2-4″	12 x 16	50	20	10	20	10	5	65

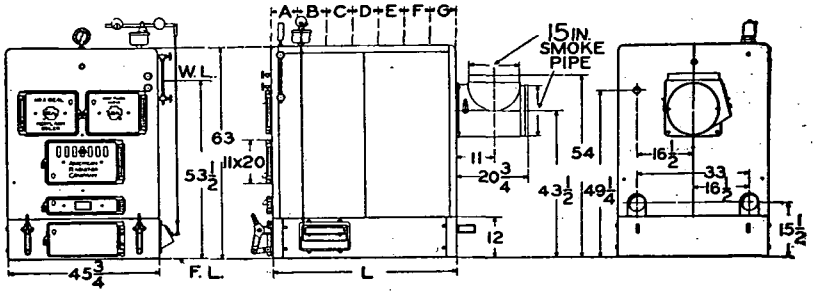
SMOKELESS—WATER

Number of Boiler	Rating Water Sq. Ft.	Grate Area Sq. Ft.	Outlets No. and Size	Inlets No. and Size	Chimney		Dimensions—Inches For Locating Flow Tappings					
					Size Inches	Height Feet	A	B	C	D	E	L
2-W-8-S	3,000	6.17	2-3½″	2-4″	12 x 12	40	15	20	..	..	5	40
2-W-9-S	3,400	7.06	2-3½″	2-4″	12 x 16	40	20	20	..	..	5	45
2-W-10-S	3,800	7.95	2-3½″	2-4″	12 x 16	45	15	30	..	..	5	50
2-W-11-S	4,300	8.84	3-3½″	2-4″	12 x 16	45	10	20	20	..	5	55
2-W-12-S	4,600	9.73	3-3½″	2-4″	12 x 16	50	15	30	10	..	5	60
2-W-13-S	5,000	10.62	4-3½″	2-4″	12 x 16	50	20	10	20	10	5	65

Data and Measurements

NO. 3 IDEAL REDFLASH SMOKELESS BOILER

Burns All Grades of Soft Coal Smokelessly



SMOKELESS—STEAM

Number of Boiler	Rating Steam Sq. Ft.	Grate Area Sq. Ft.	Outlets No. and Size	Inlets No. and Size	Chimney		Dimensions—Inches For Locating Flow Tappings							
					Size Inches	Height Feet	A	B	C	D	E	F	G	L
3-S-8-S	3,500	9.35	3–3½″	2–5″	16 x 16	50	9	18	12	..	..	..	9	48
3-S-9-S	4,000	10.70	4–3½″	2–5″	16 x 20	50	9	12	12	12	..	..	9	54
3-S-10-S	4,500	12.05	4–3½″	2–5″	16 x 20	55	9	12	12	12	..	..	15	60
3-S-11-S	5,000	13.40	4–3½″	2–5″	20 x 20	60	9	12	18	18	..	..	9	66
3-S-12-S	5,500	14.75	5–3½″	2–5″	20 x 20	65	9	18	12	12	12	..	9	72
3-S-13-S	6,000	16.10	5–3½″	2–5″	20 x 20	65	9	18	18	12	12	..	9	78
3-S-14-S	6,500	17.45	6–3½″	2–5″	20 x 20	70	9	12	12	18	12	12	9	84

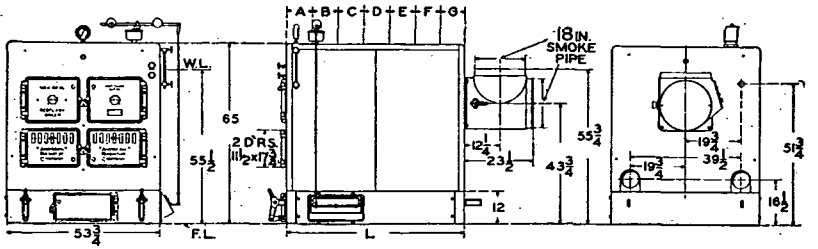
SMOKELESS—WATER

Number of Boiler	Rating Water Sq. Ft.	Grate Area Sq. Ft.	Outlets No. and Size	Inlets No. and Size	Chimney		Dimensions—Inches For Locating Flow Tappings							
					Size Inches	Height Feet	A	B	C	D	E	F	G	L
3-W-8-S	5,800	9.35	3–3½″	2–5″	16 x 16	50	9	18	12	..	..	..	9	48
3-W-9-S	6,600	10.70	4–3½″	2–5″	16 x 20	50	9	12	12	12	..	..	9	54
3-W-10-S	7,400	12.05	4–3½″	2–5″	16 x 20	55	9	12	12	12	..	..	15	60
3-W-11-S	8,200	13.40	4–3½″	2–5″	20 x 20	60	9	12	18	18	..	..	9	66
3-W-12-S	9,000	14.75	5–3½″	2–5″	20 x 20	65	9	18	12	12	12	..	9	72
3-W-13-S	9,800	16.10	5–3½″	2–5″	20 x 20	65	9	18	18	12	12	..	9	78
3-W-14-S	10,600	17.45	6–3½″	2–5″	20 x 20	70	9	12	12	18	12	12	9	84

Data and Measurements

NO. 4 IDEAL REDFLASH SMOKELESS BOILER

Burns All Grades of Soft Coal Smokelessly



SMOKELESS—STEAM

Number of Boiler	Rating Steam Sq. Ft.	Grate Area Sq. Ft.	Outlets No. and Size	Inlets No. and Size	Chimney		Dimensions—Inches For Locating Flow Tappings							
					Size Inches	Height Feet	A	B	C	D	E	F	G	L
4-S-9-S	6,500	15.66	4–4″	2–6″	20 x 20	55	10½	14	14	14	..	..	10½	63
4-S-10-S	7,250	17.64	4–4″	2–6″	20 x 20	60	10½	14	14	14	..	..	17½	70
4-S-11-S	8,000	19.62	5–4″	2–6″	20 x 24	65	10½	14	14	14	14	..	10½	77
4-S-12-S	8,750	21.60	5–4″	2–6″	20 x 24	70	10½	14	14	14	14	..	17½	84
4-S-13-S	9,500	23.58	6–4″	2–6″	20 x 24	75	10½	14	14	14	14	14	10½	91
4-S-14-S	10,250	25.56	6–4″	2–6″	20 x 24	75	10½	14	14	14	14	14	17½	98

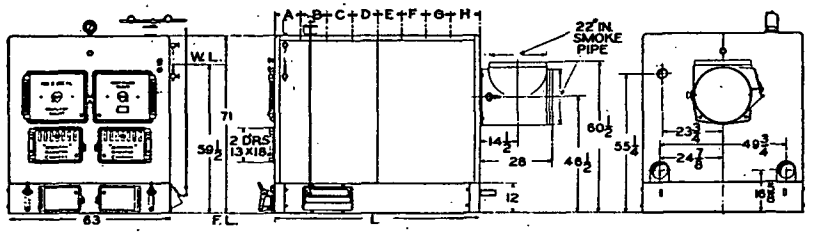
SMOKELESS—WATER

Number of Boiler	Rating Water Sq. Ft.	Grate Area Sq. Ft.	Outlets No. and Size	Inlets No. and Size	Chimney		Dimensions—Inches For Locating Flow Tappings							
					Size Inches	Height Feet	A	B	C	D	E	F	G	L
4-W-9-S	11,000	15.66	4–4″	2–6″	20 x 20	55	10½	14	14	14	..	..	10½	63
4-W-10-S	12,250	17.64	4–4″	2–6″	20 x 20	60	10½	14	14	14	..	..	17½	70
4-W-11-S	13,500	19.62	5–4″	2–6″	20 x 24	65	10½	14	14	14	14	..	10½	77
4-W-12-S	14,750	21.60	5–4″	2–6″	20 x 24	70	10½	14	14	14	14	..	17½	84
4-W-13-S	16,000	23.58	6–4″	2–6″	20 x 24	75	10½	14	14	14	14	14	10½	91
4-W-14-S	17,250	25.56	6–4″	2–6″	20 x 24	75	10½	14	14	14	14	14	17½	98

Data and Measurements

NO. 5 IDEAL REDFLASH SMOKELESS BOILER

Burns All Grades of Soft Coal Smokelessly

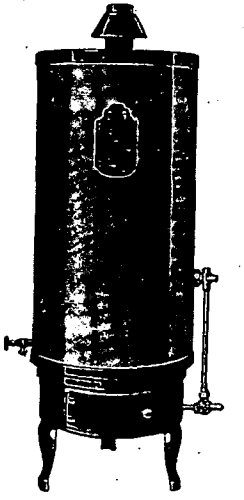


SMOKELESS—STEAM

Number of Boiler	Rating Steam Sq. Ft.	Grate Area Sq. Ft.	Outlets No. and Size	Inlets No. and Size	Chimney		Dimensions—Inches For Locating Flow Tappings								
					Size Inches	Height Feet	A	B	C	D	E	F	G	H	L
S-S-9-S	9,100	21.52	4-5"	2-6"	24 x 28	75	12	16	16	16	..	..	..	12	72
S-S-10-S	10,200	24.21	4-5"	2-6"	24 x 28	75	12	16	24	16	..	..	..	12	80
S-S-11-S	11,300	26.90	5-5"	2-6"	24 x 28	80	12	16	16	16	16	..	..	12	88
S-S-12-S	12,400	21.52	5-5"	2-6"	24 x 28	85	12	16	16	16	16	..	..	20	96
S-S-13-S	13,500	24.21	5-5"	2-6"	30 x 36	85	12	16	24	16	24	..	..	12	104
S-S-14-S	14,600	24.21	6-5"	2-6"	30 x 36	90	12	16	16	24	16	16	..	12	112
S-S-15-S	15,700	26.90	6-5"	2-6"	30 x 36	95	12	16	24	16	24	16	..	12	120
S-S-16-S	16,800	26.90	7-5"	2-6"	30 x 36	100	12	16	16	16	16	16	16	20	128
S-S-17-S	17,900	26.90	7-5"	2-6"	30 x 36	105	12	16	24	16	24	16	16	12	136

SMOKELESS—WATER

Number of Boiler	Rating Water Sq. Ft.	Grate Area Sq. Ft.	Outlets No. and Size	Inlets No. and Size	Chimney		Dimensions—Inches For Locating Flow Tappings								
					Size Inches	Height Feet	A	B	C	D	E	F	G	H	L
S-W-9-S	15,000	21.52	4-5"	2-6"	24 x 28	75	12	16	16	16	..	..	..	12	72
S-W-10-S	16,800	24.21	4-5"	2-6"	24 x 28	75	12	16	24	16	..	..	..	12	80
S-W-11-S	18,600	26.90	5-5"	2-6"	24 x 28	80	12	16	16	16	16	..	..	12	88
S-W-12-S	20,400	21.52	5-5"	2-6"	24 x 28	85	12	16	16	16	16	..	..	20	96
S-W-13-S	22,200	24.21	5-5"	2-6"	30 x 36	85	12	16	24	16	24	..	..	12	104
S-W-14-S	24,000	24.21	6-5"	2-6"	30 x 36	90	12	16	16	24	16	16	..	12	112
S-W-15-S	25,800	26.90	6-5"	2-6"	30 x 36	95	12	16	24	16	24	16	..	12	120
S-W-16-S	27,600	26.90	7-5"	2-6"	30 x 36	100	12	16	16	16	16	16	16	20	128
S-W-17-S	29,400	26.90	7-5"	2-6"	30 x 36	105	12	16	24	16	24	16	16	12	136



IDEAL "HOTCOIL" Gas Water Heater

The New Hotcoil Water Heater functions with the highest degree of operating efficiency attainable for practical service.

With green porcelain enamel top and base, in combination with the pearl-gray jacket, the beauty of this heater is virtually everlasting.

The Hotcoil Heater unites "flash" heating with the automatic storage factor, embodying the advantages of all other types of water heaters.

Specifications

1—Special brass hot water flow-fitting.

2—Non-destructible metal jacket with beautiful pearl gray baked enamel finish.

3—Substantial heavy gauge tank, galvanized inside and outside.

4—Conveniently located brass drain cock.

5—Large bore, heavy gauge, one-piece copper coil heating element, insuring immediate hot water recovery.

6—Bunsen type gas burner with self pilot.

7—Porcelain enamel Back Draft Diverter Hood.

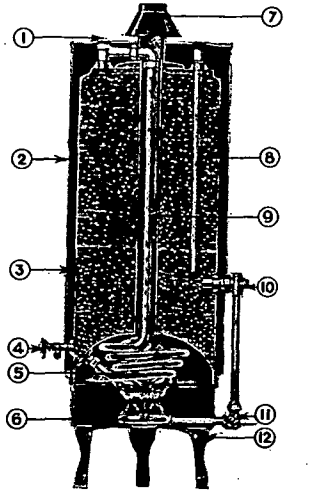
8—Non-syphon acting cold water intake.

9—Central water-surrounded flue containing copper coil heating element.

10—New Arco Automatic regulator with quick acting metallic bellows.

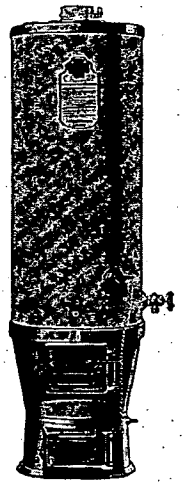
11—Main Gas Supply Control Valve and Dial.

12—Substantial base and legs with porcelain enamel finish.



Made in three sizes, 20, 30, 40 gallons.
Burns manufactured, mixed, or natural gas.

IDEAL "KOLFLASH" Coal-burning Water Heater

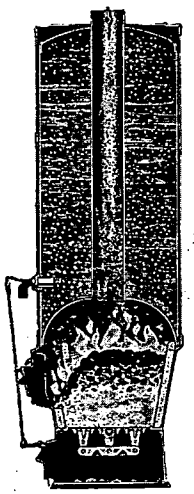


The firepot of the Kolflash Heater is made of cast iron with a one-inch non-heat-conducting refractory lining. Under ordinary operating conditions the temperature of the smooth, enameled and non-water-backed exterior of the firepot is no higher than the temperature of the water in the tank.

This lining not only contributes to the efficiency of the heater, but also provides for a quick pick-up capacity. For the lining retains the heat of the fire, and after a shaking-down and the addition of more fuel, the new charge of coal quickly ignites. The radiant heat of the glowing coals plays directly on the broad bottomed, water-backed surface of the tank, and the heated water rises, extracting increasing amounts of heat from the gases in the central flue.

The Ideal Kolflash Heater has been designed with deep firepot especially to provide for long firing periods.

Specifications



Large combustion chamber insures minimum attention.

For ordinary household demands this heater need be fired but twice a day.

One inch, non-heat-conducting refractory lining in firepot, prevents heat loss and insures quick pick-up heating capacity.

Water-surrounded flue insures maximum absorption of heat from the gases.

Extra-heavy shell insures durable service.

Arco Automatic Regulator keeps water at right temperature.

Flexible, sturdy grating especially designed for easy caretaking.

Outside jacket finished in beautiful French pearl gray. Base and top finished in beautiful green porcelain enamel.

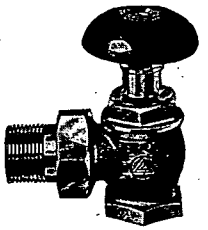
AMERICAN RADIATOR COMPANY

General Sales and Eastern Executive Office
40 West 40th Street, New York

Western Executive Office and Accessories Division
816 South Michigan Avenue, CHICAGO, ILLINOIS

Manufacturers of Ideal Boilers, American Corto Radiators, and other Heating, Ventilating, and Refrigerating Products

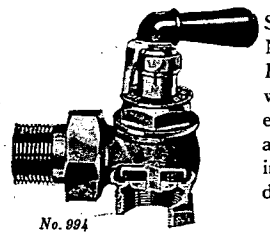
PACKLESS VALVE



No. 999

Arco Packless No. 999—leak-proof—does not require repacking. Does not stick or bind—opens with one smooth turn of special composition handle never gets hot. Furnished in either round or lever handle—made in angle, corner and globe patterns for steam, water, vapor or vacuum.

Arco Fractional Control Type No. 994

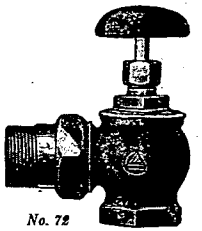


No. 994

Same as the No. 999 Packless with dial equipment and calibrating cone on disc.

PACKED VALVES

Detroit Steam Valves

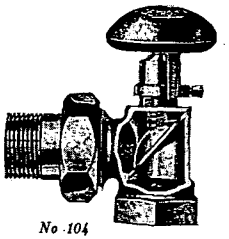


No. 72

Metal well distributed—strong and heavy where strength is needed. Regularly equipped with composition handle, black hard rubber finish.

No. 72 Angle, No. 32 R. H. Corner, No. 37 L. H. Corner, No. 57 Globe, No. 373 Gate.

Detroit Equalizing Hot Water Valve No. 104



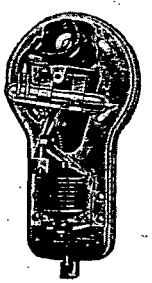
No. 104

Opens and closes smoothly—never sticks or binds. The narrow edge of the plate presents a small area of contact so that corrosion is easily broken away.

Made in angle pattern only—Lever handle No. 105.

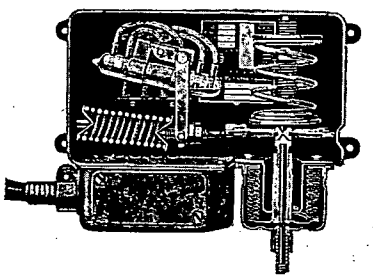
MERCOID CONTROLS

PATENTS PENDING

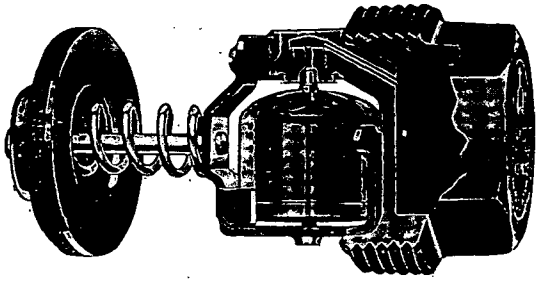


No. 845 Thermostat

All Mercoid Controls employ the Mercoid Switch which carries the full line current at 110 or 220 volts without arcing or corrosion of contacts. Mercoid instruments give automatic control of temperature, pressure or vacuum. The various models provide a wide field of application. The No. 845 Mercoid Thermostat is especially adapted for use with Unit Heaters—starting or stopping the fan as the air temperature changes. The No. 847 Arco Motor Valve, for high or low pressure steam, water, air, etc., can be used with any Mercoid Control. Write for full details of this complete line.



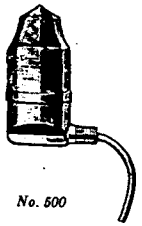
No. 848 Type
For temperature, pressure, or vacuum



IN-AIRID The Invisible Air Valve

The IN-AIRID No. 1 is a new type automatic air valve especially designed to prevent the short circuiting of steam in new water type radiation. The IN-AIRID screws into the top plug opening in the vent end of the radiator and its baffle disc completely blocks off the opening to the last section. The operation of IN-AIRID is based on the same well known principle of the thermostatically charged float used so successfully in the famous Airid No. 500.

The IN-AIRID No. 2 is for "below atmosphere" jobs. It has all the venting features of the No. 1, plus the vacuum seal with hand lapped monel disc and seat. It allows the air to escape but prevents its return into the system.

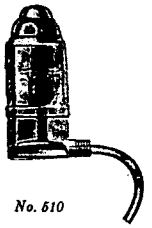


No. 500

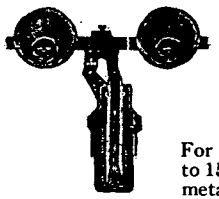
AIRID AIR VALVES

The Airid No. 500 should be installed only on old style radiation which has nipple connections only at the bottom. On new type radiation with nipple connections at the top use the IN-AIRID.

Vac-Airid No. 510 is for "below atmosphere" jobs on old style radiation. It is designed to allow the air to escape but prevents its return into the system.



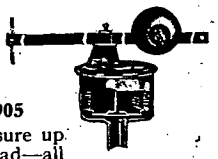
No. 510



No. 800

ARCO REGULATORS

Arco Water Regulator No. 800 is for damper control on hot water heating boilers, adjustable for temperature between 100 deg. and 220 deg.—all metal—length of bulb, 2½ inches; connection, 2 inches.



No. 905

ARCO STEAM REGULATOR NO. 905

For damper control on steam boilers—pressure up to 15 lbs. Connection 1 inch I.P.S. male thread—all metal—trimmings furnished.

IDEAL QUICK VENT NO. 815

All metal for venting mains, long runs of pipe, indirect stacks, drop risers, etc. Very sensitive. No. 815, ¾ in.; No. 820, ⅜ in.



No. 821

IDEAL FLOAT QUICK VENT NO. 821

For free venting mains, indirect stacks, vento, etc. Closes against water. No. 821, ¾ in.

VAC-VENT NO. 822

For vacuum heating, No. 822 Vac-Vent is self-sealing against the return of air. No. 822, ¾ in.



No. 815

American Radiator Company

IDEAL GAS BOILERS

Distributor

American Gas Products Corporation

376 Lafayette Street, New York

Ideal Gas Boilers

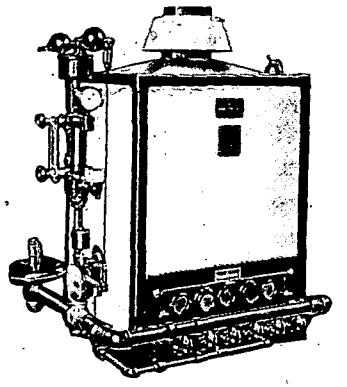
for house-heating, domestic hot-water supply and general industrial use

A complete line of durable cast-iron boilers specially designed to burn gas at the highest possible efficiency. They are supplied with complete automatic control equipment for steam, vapor or water heating systems, including thermostatic pilot and low water cut-out.

Ideal Gas Boilers are produced complete—from castings to control valves—by one company, making it possible to maintain a single high standard of quality with a single manufacturing profit.

The heavily insulated jackets are attractive to the eye, easily kept clean and absolutely impervious to corrosion. All metal parts, such as diverters, canopies and trimmings are given a lustrous porcelain finish applied at high temperatures in our own enamelling ovens.

A. G. A. Approved; recommended by leading gas companies and accepted as standard by architects, heating contractors and engineers. Will heat anything from a three room cottage to the largest buildings.



Ideal Type 4G Gas Boiler

RATINGS—DIMENSIONS

Boiler No.	A G A RATINGS: Steam Water Sq. Ft.	Steam Water Sq. Ft.	Output B.t.u.	Boiler Hp.	DIMENSIONS: No. of Sections	No. of Burners	No. and Size of Gas Supply Lines In.	Size of Burner Manifold In.	No. and Size of Tappings: Supply In.	Tappings: Return In.	No. and Size of Flue Connec. Diam. In.	Width In.	Depth In.	Overall Height Incl. Diverters In.	Water Line In.
0-G-4	270	435	64,000	1.9	4	3	1-1	1	1-2½	1-2½	1-5	18½	13¾	54	32
0-G-5	340	545	81,000	2.4	5	3	1-1	1	1-2½	1-2½	1-5	18½	16¾	54	32
0-G-6	410	655	98,200	2.9	6	3	1-1	1	1-2½	1-2½	1-6	18½	19¾	55	32
0-G-7	480	765	115,200	3.4	7	3	1-1	1	1-2½	1-2½	1-6	18½	22¾	55	32
1-G-4	550	880	132,000	3.9	4	3	1-1¼	1½	2-4	2-4	1-6	18½	24¾	52½	30
1-G-5	710	1130	170,000	5.1	5	4	1-1¼	1½	2-4	2-4	1-7	22½	24¾	52½	30
1-G-6	870	1390	208,000	6.2	6	5	1-1½	1½	2-4	2-4	1-8	26½	24¾	53	30
1-G-7	1025	1640	246,000	7.3	7	6	1-1½	1½	2-4	2-4	1-8	30½	24¾	53¾	30
1-G-8	1185	1890	284,000	8.5	8	7	1-1½	1½	2-4	2-4	1-8	34½	24¾	54½	30
1-G-9	1340	2150	322,000	9.6	9	8	1-1½	1½	2-4	2-4	1-9	38½	24¾	57½	30
1-G-10	1500	2400	360,000	10.7	10	9	1-2	1½	2-4	2-4	1-9	42½	24¾	58¼	30
1-G-11	1660	2650	398,000	11.9	11	10	1-2	1½	2-4	2-4	1-10	46½	24¾	58¾	30
4-G-6	2000	3200	480,000	14.3	6	5	1-2	2	1-6	1-5	1-11	27	41½	69	43
4-G-7	2400	3840	576,000	17.2	7	6	1-2	2	1-6	1-5	1-11	31	41½	69¾	43
4-G-8	2800	4480	672,000	20.0	8	7	1-2	2	1-6	1-5	1-12	35	41½	70¼	43
4-G-9	3200	5120	768,000	22.9	9	8	1-2½	2	1-6	1-5	1-12	39	41½	71	43
4-G-10	3600	5760	864,000	25.8	10	9	1-2½	2	1-6	1-5	1-13	43	41½	73	43
4-G-11	4000	6400	960,000	28.6	11	10	1-2½	2	1-6	1-5	1-14	47	41½	73½	43
4-G-13	4800	7680	1,152,000	34.4	13	12	1-2½	2½	2-6	1-5	2-11	61	41½	69	43
4-G-15	5600	8960	1,344,000	40.0	15	14	1-2½	2½	2-6	1-5	2-12	69	41½	70¼	43
4-G-17	6400	10240	1,536,000	45.8	17	16	1-3	2½	2-6	1-5	2-12	77	41½	71	43
4-G-19	7200	11520	1,728,000	51.6	19	18	1-3	2½	2-6	1-5	2-13	85	41½	73	43
4-G-21	8000	12800	1,920,000	57.2	21	20	1-3	2½	2-6	1-5	2-14	93	41½	73½	43
4-G-22	8400	13440	2,016,000	60.0	22	21	1-3	2½	4-6	2-5	3-12	101	41½	70¼	43
4-G-25	9600	15360	2,304,000	68.7	25	24	2-2½	2½	4-6	2-5	3-12	115	41½	71	43
4-G-28	10800	17280	2,592,000	77.4	28	27	2-2½	2½	4-6	2-5	3-13	127	41½	73	43
4-G-31	12000	19200	2,880,000	85.8	31	30	2-3	2½	4-6	2-5	3-14	139	41½	73½	43
4-G-33	12800	20480	3,072,000	91.6	33	32	2-3	2½	6-6	3-5	4-12	153	41½	71	43
4-G-37	14400	23040	3,456,000	103.2	37	36	2-3	2½	6-6	3-5	4-13	169	41½	73	43
4-G-41	16000	25600	3,840,000	114.4	41	40	2-3	2½	6-6	3-5	4-14	185	41½	73½	43

N. B. When specified, additional tappings available; 4-G-6 to 4-G-11 = 1-6 in. supply and 1-5 in. return.
N. B. When specified, additional tappings available, 4-G-13 to 4-G-41 = 2-6 in. supply and 2-5 in. return.

The Bigelow Company

ESTABLISHED 1860

Main Office and Works

New Haven, Connecticut

NEW YORK OFFICE—Graybar Building

Manufacturers of

Bigelow Hornsby Water Tube Boilers
Bigelow Horizontal Water Tube Boilers
Bigelow Horizontal Return Tubular Boilers
Bigelow Electric Steam Generators
Bigelow Two Pass Boilers
Bigelow Manning Boilers
Bigelow Upright Boilers

The Bigelow Two Pass Boiler for Heating and Power

The requirements in considering a boiler especially for steam heating—are first cost, efficiency and maintenance, and the steel heating boiler particularly the Bigelow Two Pass type we believe meets the above desired requirements most favorably.

First Cost—The F. O. B. price of a steel boiler is often higher than for other types, but, of course, the installed cost is the correct way to figure. For the proper erection of a sectional boiler experienced and high priced men are required while the Bigelow Two-Pass Boiler is shipped practically all assembled and requires but a small amount of mason work.

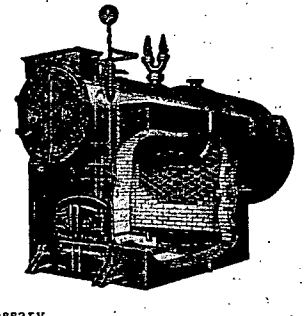
Efficiency—Correctly designed as a heat absorbing piece of apparatus, the area of the gas passage in the first pass is approximately one third greater than that of the return pass. This results in better heat transmission, due to the more uniform velocity of the gases over the heating surface as they are cooled.

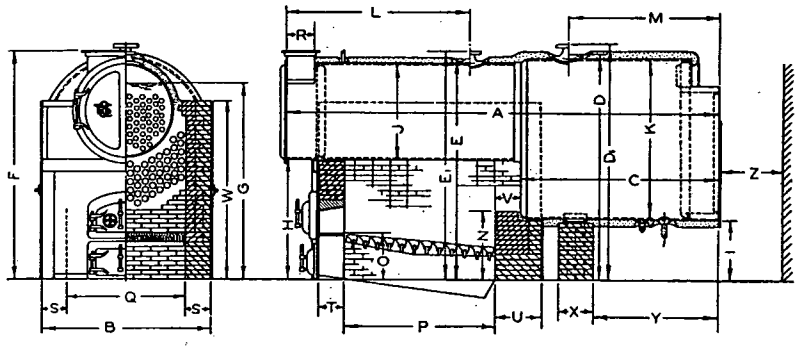
The furnace is constructed of standard fire and red brick and is encased in a heavy sectional plate steel casing which adds to the neat appearance of the installation and prevents infiltration of air through cracks that may develop in the brick work.

Maintenance—The Bigelow Two-Pass Boiler is constructed without crown sheet or water legs, so there are no staybolts to break and cause leakage or danger of rupture. Being constructed of steel, there is no likelihood of cracking sections due to sudden changes of temperature, variation in thickness of material under pressure, and no unequal strains are set up in assembling. The many installations of the Bigelow Two-Pass Boiler both for heating and power, have proven it to be economical in operation and low in maintenance cost.

Features of the Bigelow Two-Pass Boiler

No Staybolts
Easy to Install
Quick Steamer
Low Draft Loss
Easy to Handle
Long Gas Travel
Efficient to Operate
Low Maintenance Cost
Ample Water Capacity
Occupies Small Floor Space
Low Exit Gas Temperature
Ample Steam Storage Capacity
Inside of Boiler Readily Accessible
Furnace Suitable for Oil Burning
No Cast Iron in Contact with Pressure
Large Furnace Volume for Combustion
Area of Gas Passes Properly Proportioned
No Special Brick Shapes Required for Furnace
Constructed to A.S.M.E., or Mass. State Requirements
Fire Brick Furnace Walls, which Aids Combustion
Built in Units of 25, 50, 75, 100, 125 and 150 hp.
All Sizes Built as a Standard for 15 and 125 lb. W. P.
Brick Work Easily and Cheaply Repaired when Necessary
Boiler Rating Based on 10 sq. ft. of Water Heating Surface per hp.





GENERAL INFORMATION OF BIGELOW TWO-PASS BOILER

No. of Boiler for		240H	241H	242H	243H	244H	245H
Heating, 15 lb. W. P.							
Power, 125 lb. W. P.		240	241	242	243	244	245
Total Heating Surface sq. ft.		270	505	751	1003	1273	1501
Capacity Steam Radiation sq. ft.		3200	6000	9000	12000	15200	18000
Capacity Water Radiation sq. ft.		5300	10000	14800	19800	25200	29700
Grate Area sq. ft.		12.3	16.5	20.8	28.0	31.0	33.5
Diameter stack, one boiler in.		16	20	24	27	30	30
Diameter stack, two boilers in.		20	27	30	34	38	42
Height stack feet		60	60	60	60	60	60
Area breeching, one boiler sq. ft.		1.3	2.2	3.0	3.8	4.5	5.2
Area breeching, two boilers sq. ft.		2.2	3.8	5.2	6.3	8.0	9.4
Size of steam nozzle, 15 lb. W. P. in.		6	6	8	8	8	8
Size of steam nozzle, 125 lb. W. P. in.		3	4	5	5	6	6
Size of safety valve nozzle, 15 lb. W. P. in.		2	2½	3	4	4	4
Size of safety valve nozzle, 125 lb. W. P. in.		3	4	4	4	5	5
No. and size pop valves, 15 lb. W. P. in.		1-2"	1-2½"	1-3"	1-3½"	1-4"	1-4"
No. and size pop valves, 125 lb. W. P. in.		1-2"	2-2"	2-2"	2-2½"	2-2½"	2-3"
Blow down and return conn., 15 lb. W. P. in.		3	3	4	4	4	4
Blow-off connection, 125 lb. W. P. in.		2	2	2	2	2	2½
No. red brick required		1400	1550	1650	2100	2300	3000
No. fire brick required		550	625	700	800	900	1100
Area of shell to be insulated sq. ft.		100	120	145	170	195	220
Weight bare boiler lbs.		4675	8482	10732	14000	16717	18823
Weight boiler comp. catgs., trmgs. and steel casing lbs.		7993	12492	15607	19841	23133	25859
Length over all ft. in.	A	11' 9"	13' 0"	14' 1"	16' 2"	16' 4"	18' 10"
Width overall ft. in.	B	5' 4"	5' 11"	6' 5"	6' 11"	7' 5"	7' 5"
Length large shell ft. in.	C	5' 8"	6' 2"	6' 8"	7' 8"	7' 8"	8' 8"
Steam outlet to floor, 15 lb. W. P. ft. in.	D	7' 8½"	8' 2½"	9' 0"	9' 4"	10' 1"	10' 1"
Steam nozzle to floor, 125 lb. W. P. ft. in.	D1	7' 10½"	8' 5½"	9' 2½"	9' 6½"	10' 3½"	10' 3½"
Safety valve outlet to floor, 15 lb. W. P. ft. in.	E	7' 5¼"	7' 10½"	8' 7½"	8' 11¾"	9' 7¾"	9' 7¾"
Safety valve noz. to floor, 125 lb. W. P. ft. in.	E1	7' 8"	8' 2"	8' 11"	9' 3"	9' 11"	9' 11"
Flue neck to floor ft. in.	F	7' 9½"	8' 3½"	9' 0½"	9' 4½"	10' 0½"	10' 0½"
Water line to floor ft. in.	G	6' 5¼"	6' 11⅝"	7' 8⅝"	7' 11¼"	8' 6⅜"	8' 6⅜"
Floor to shell at front of boiler ft. in.	H	4' 7"	4' 7"	5' 0"	5' 0"	5' 4"	5' 4"
Floor to shell at rear of boiler ft. in.	I	2' 10"	2' 4"	2' 7"	2' 5"	2' 7"	2' 7"
Diameter of small shell in.	J	32"	38"	42"	46"	50"	50"
Diameter of large shell in.	K	54"	66"	72"	78"	84"	84"
Front of boiler to C safety valve nozzle, ft. in.	L	3' 4"	4' 7"	5' 3"	6' 3"	6' 5"	8' 0"
Rear of boiler to C steam nozzle, ft. in.	M	4' 2"	4' 2"	4' 7"	5' 8"	5' 8"	6' 7"
Height of bridge wall ft. in.	N	3' 3"	3' 0"	3' 1"	2' 11"	2' 11"	2' 11"
Grate to floor ft. in.	O	2' 1"	2' 1"	2' 1"	2' 1"	2' 1"	2' 1"
Length of furnace ft. in.	P	4' 0"	4' 6"	5' 0"	6' 0"	6' 0"	6' 6"
Width of furnace ft. in.	Q	3' 1"	3' 8"	4' 2"	4' 8"	5' 2"	5' 2"
Size of flue neck in.	R	8"x22"	11"x24"	12½"x32"	13½"x36"	15½"x40"	15½"x42"
Thickness of side wall in.	S	13½"	13½"	13½"	13½"	13½"	13½"
Thickness of front wall in.	T	9"	9"	9"	9"	9"	13½"
Thickness of bridge wall at bottom ft. in.	U	1' 4"	1' 4"	1' 4"	1' 4"	1' 4"	2' 0"
Thickness of bridge wall at top in.	V	6½"	6½"	6½"	6½"	6½"	14"
Floor to top of setting ft. in.	W	6' 5"	6' 8"	7' 3"	7' 5"	7' 5"	7' 5"
Depth and width of rear pier ft. in.	X	1' 0"x3' 0"	1' 0"x3' 0"	1' 0"x3' 6"	1' 4"x4' 0"	1' 6"x4' 6"	1' 6"x4' 6"
Back of pier to rear of boiler ft. in.	Y	3' 1½"	3' 7½"	4' 1½"	4' 9½"	4' 7½"	5' 7"
Distance required to open rear cleanout doors ft. in.	Z	1' 10"	2' 1"	2' 4"	2' 6"	2' 10"	2' 10"

Burnham Boiler Corporation

Irvington-on-Hudson, New York

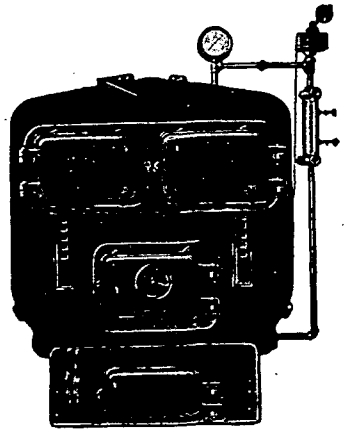
Makers of High and Low Pressure Cast Iron Heating Boilers

New York Office: GRAYBAR BUILDING

Offices: BOSTON, PHILADELPHIA, CHICAGO, BALTIMORE, QUEENS VILLAGE, L. I., SAN FRANCISCO

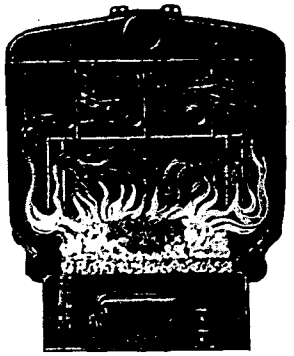
Plants at IRVINGTON, N. Y., ELIZABETH, N. J., LANCASTER, PA.

There's a Burnham for Every Heating Purpose



Burnham Smokeless Boilers

For Steam and Hot Water Heating



SPECIALLY designed for soft coal burning. Sectional construction. Inside sections interchangeable. As easy to erect and operate as any Burnham Sectional Boiler. Burns the most volatile of soft coal, in conformity to smoke regulations of all cities. Has the extra long fire travel that is a feature of all Burnham Boilers. It gets all the usable heat. *Send for Smokeless Boiler Folder.*

RATINGS FOR STEAM

Size	No. of Sections	Rating	Sq. Ft. Grate Area	Tappings		Chimney Size	Overall Length
				Supply	Return		
638-S	6	5625	11.9	3-5"	3-5"	16"x16"x50'	74"
738-S	7	6875	14.3	3-5"	3-5"	16"x16"x55'	83"
838-S	8	7875	16.6	3-5"	3-5"	16"x16"x60'	92"
938-S	9	9000	19.1	4-5"	4-5"	20"x20"x60'	101"
1038-S	10	10,125	21.5	4-5"	4-5"	20"x20"x65'	110"
1138-S	11	11,250	23.9	4-5"	4-5"	24"x24"x65'	120"
1238-S	12	12,500	26.3	5-5"	5-5"	24"x24"x70'	129"

RATINGS FOR HOT WATER

638-W	6	9,000	11.9	3-5"	3-5"	16"x16"x50'	74"
738-W	7	11,000	14.3	3-5"	3-5"	16"x16"x55'	83"
838-W	8	12,600	16.6	3-5"	3-5"	16"x16"x60'	92"
938-W	9	14,400	19.1	4-5"	4-5"	20"x20"x60'	101"
1038-W	10	16,200	21.5	4-5"	4-5"	20"x20"x65'	110"
1138-W	11	18,000	23.9	4-5"	4-5"	24"x24"x65'	120"
1238-W	12	20,000	26.3	5-5"	5-5"	24"x24"x70'	129"

Width Overall—60 in. Height Water Line—63 in. Height to Supply Tapping—75 in.
Size Smoke Pipe—18 in. 6, 7, 8 Section Boilers; 20 in. 9, 10, 11, 12 Section Boilers.

Catalogue gives full information concerning the full line of Burnham Boilers for Heating and Hot Water Supply.

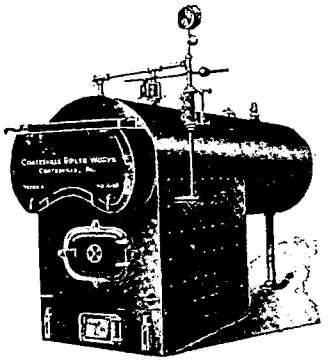
Coatesville Boiler Works

Coatesville, Pa.

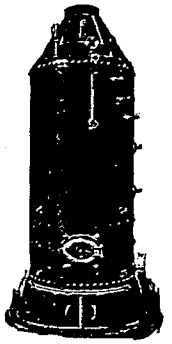
Main Office and Works: COATESVILLE, PA.

PHILADELPHIA, 111 S. 15th St. NEW YORK, 30 Church St. BOSTON, 141 Milk St. SAN FRANCISCO, 945 Pine St.
PITTSBURGH, Union Trust Bldg. BALTIMORE, Lexington Bldg. NEWARK, 60 Park Place

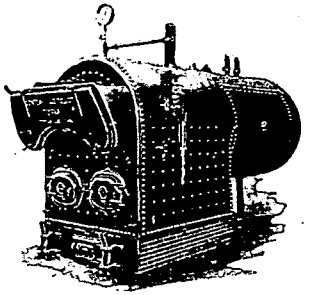
Heating and Power Boilers—Steel Tanks—Heavy Steel Plate Work



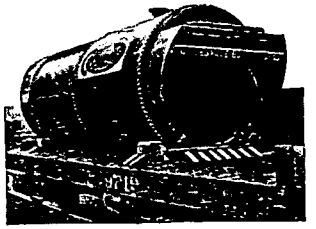
Coatesville "Series A" Welded Heating Boiler 15 lb. Working Pressure



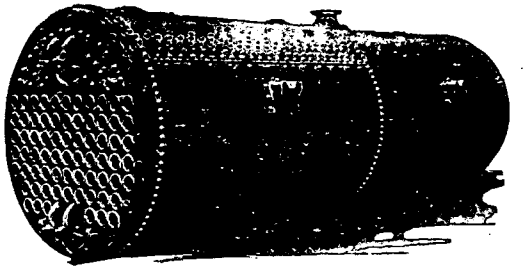
Coatesville Vertical Boiler, 100 and 125 lb. Working Pressure



Coatesville Riveted Fire Box Boiler Heating and Power



Coatesville Scotch Marine Type Boiler Power and Heating



Coatesville Horizontal Return Tubular Boiler, Power and Heating

Heating and Power Boilers.—We manufacture a complete line of steel heating and power boilers, suitable for Anthracite and Bituminous coal, Oil or Gas fuel. Note illustrations above.

Steel Tanks.—We carry storage tanks in stock to meet quick delivery requirements. We manufacture tanks for all purposes—House tanks, Storage tanks, Sump tanks, Sprinkler tanks, Blow-off tanks, Water tanks, Tanks for fuel oil, Pressure tanks.

Miscellaneous Steel Plate Construction.—Steel smoke stacks, Breechings, Chutes, Hoppers, Air ducts, Bins and all special lines of steel plate work.

Electric Welding.—This department is well equipped with modern welding machines and experienced operators. Many orders for storage tanks and miscellaneous steel plate work can be economically fabricated of welded construction.

Literature.—We have just issued a new series of Bulletins regarding our line of Portable Fire Box Steel Heating Boilers for Power and Heating purposes. Ask for Bulletin giving specifications of the particular type of boiler in which you are interested.

Bulletins regarding tanks and Steel Plate Work, also, upon request.

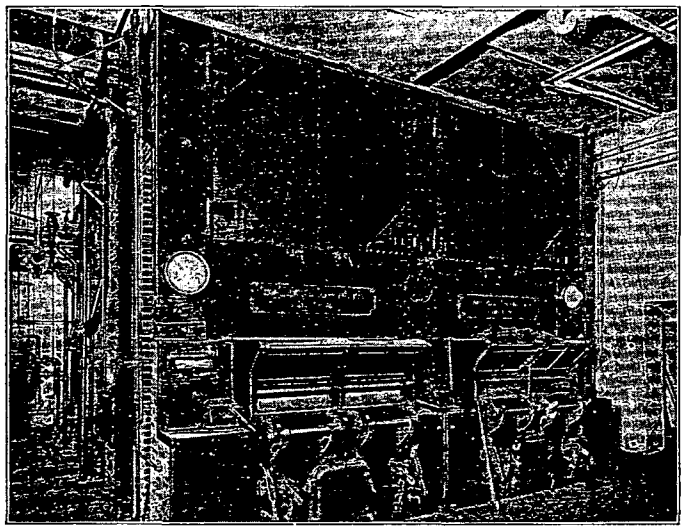
Edge Moor Iron Company

Edge Moor, Delaware

NEW YORK.....420 Lexington Ave. LOS ANGELES.....121 W. Pico St.
CHICAGO.....1549 Otis Bldg. CHARLOTTE, N. C.....1100 Realty Bldg.
ST. PAUL.....Fourth and Wacouta Sts.

Designers and Builders of

EDGE MOOR WATER TUBE BOILERS



Battery of EDGE MOOR *Heating Boilers at Homeopathic Hospital, Wilmington, Del.*

THE EDGE MOOR HEATING BOILER

An all-steel water tube boiler of high efficiency for buildings requiring 21,000 sq. ft. and more of steam radiation. Made in four sizes, from 150 hp. to 300 hp.

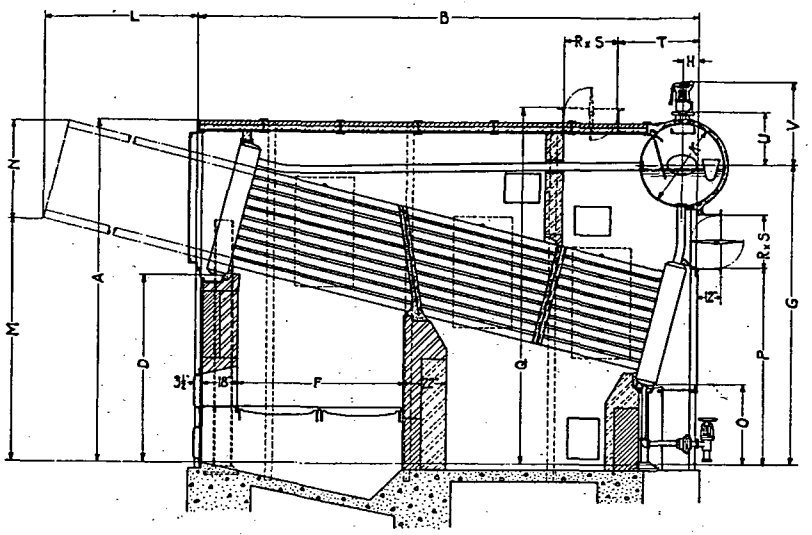
Because it is adapted to power loads up to 150 lbs. per sq. in. working pressure, this boiler is especially suitable for office buildings, hotels, large apartments, schools, hospitals, municipal buildings, theatres, garages, warehouses and similar installations where steam is required for power and other purposes in addition to heating.

The EDGE MOOR Heating Boiler follows the same general design and construction used in the EDGE MOOR Cross Drum Boiler for high-pressure service, which is serving many industries. It is built to the same high standards of quality, fully complying with all *A. S. M. E.* Code and local requirements.

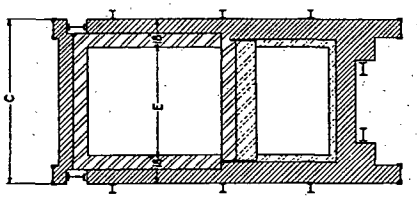
Adaptable to various fuels and firing methods, including stoker-firing.

Table on following page gives dimensions, capacities and other data.
For further information, address our nearest office.

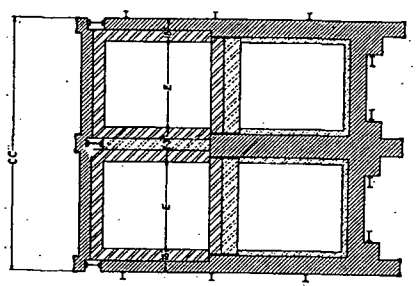
THE EDGE MOOR HEATING BOILER



SECTIONAL SIDE ELEVATION



SECTIONAL PLAN-SINGLE SETTING



SECTIONAL PLAN-BATTERY

Boiler Number		150	200	250	300
Heating Surface	sq ft	1500	2000	2500	3000
Capacity, Steam (at Normal Boiler Rating)	sq ft	21000	28000	35000	42000
A – Floor to Top of Boiler	ft-in.	14-8	14-8	14-8	14-8
B – Length of Boiler Setting	ft-in.	18-2	18-2	18-2	21-2
C – Width of Boiler Single Setting	ft-in.	8-8	10-7½	12-6½	12-6½
CC – Width of Boiler Battery Setting	ft-in.	16-7	20-6	24-4	24-4
D – Floor to Bottom of Front Header	ft-in.	8-0	8-0	8-0	8-0
E – Width of Furnace	ft-in.	5-8	7-7½	9-6½	9-6½
F – Depth of Furnace	ft-in.	7-0	7-0	7-0	7-0
G – Floor to ℄ of Drum	ft-in.	12-10⅝	12-10⅝	12-10⅝	12-10⅝
H – ℄ of Drum to Rear Face Brickwork	in.	7	7	7	8⅛
K – Diameter of Drum	in.	42	42	42	42
L – Space Required to Remove Tubes	ft-in.	14-0	14-0	14-0	17-0
M – " " " " "	ft-in.	12-4½	12-4½	12-4½	13-0
N – " " " " "	ft-in.	4-2	4-2	4-2	4-2
O – Floor to Bottom of Rear Header	ft-in.	4-2⅛	4-2⅛	4-2⅛	3-5⅛
P – Floor to Breeching Conn. Gas out Rear	ft-in.	9-2⅞	9-2⅞	9-2⅞	8-5⅛
Q – " " " " Top	ft-in.	15-2	15-2	15-2	15-2
R – Breeching Conn. Width	ft-in.	1-6	1-6	1-6	2-3
S – " " Length	ft-in.	6-7½	8-7	10-6	10-6
T – Rear of Boiler to Breeching Conn.	ft-in.	2-8	2-8	2-8	3-4½
U – ℄ Drum to Top of Steam Outlet	ft-in.	2-3½	2-3½	2-3½	2-4½
V – ℄ Drum to Top of Pop Valve	ft-in.	3-3	3-3	3-3	3-6
Number of Firebrick – Single Setting		5400	6400	6700	7700
" " Redbrick – " "		13200	17300	14200	15900
" " Firebrick – Battery "		11300	12600	13400	15900
" " Redbrick – " "		22600	25200	24700	27500
Shipping Weight of One Boiler	lbs.	39250	47300	56650	62300
Total Weight Filled with Water	lbs.	45000	57000	71500	77500

EDGE MOOR
Water Tube BOILERS

Fitzgibbons Boiler Co., Inc.

ESTABLISHED 1886

General Offices: 570 Seventh Avenue, New York City

PRODUCTS

Fitzgibbons Copper Steel Boilers for Steam or Hot Water Heating. Table 1.

Fitzgibbons Copper Steel Smokeless Boilers for Steam or Hot Water Heating. Table 1-B.

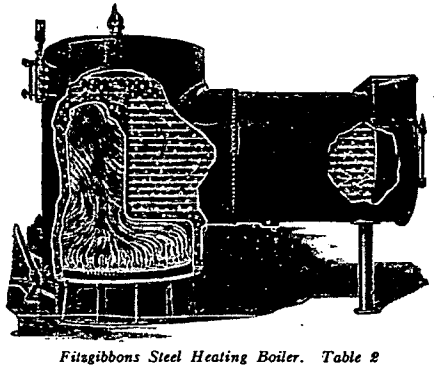
Fitzgibbons (Intermediate Sized) Steel Boilers for Steam or Hot Water Heating. Table 2.

Fitzgibbons All Riveted Steel Boilers for Heating and for Power. Table 3 and Table 4. (Not shown).

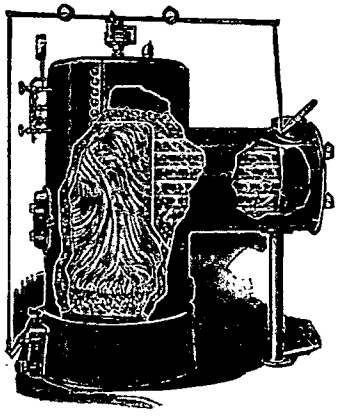
Fitzgibbons Steel Boilers: Embodying the original Fitzgibbons cylindrical furnace, entirely free from brickwork, the high combustion chamber, the gas-deflecting arch, the secondary air preheater, and the effective single pass of many relatively small tubes, Fitzgibbons Steel Boilers have, for more than forty years, proved their twin qualities, notable fuel economy and lifetime service, substantially without maintenance expense.

Construction: The cylindrical design of the Fitzgibbons Steel Boiler affords the strongest possible construction with minimum of internal bracing; and the complete water-jacketing of the vertical furnace insures exceptionally long life as well as high efficiency. The entire interior of the Boiler is visible and accessible for inspection or cleaning.

Combustion: Complete combustion of the fuel and its consumable gases is attained with a minimum of excess air. The circular Fitzgibbons grate is free from dead corners and maintains a hot, uniform fire. The wholly visible grate encourages and assists careful firing. The high cylindrical combustion chamber is now recognized as essential to complete combustion. The



Fitzgibbons Steel Heating Boiler. Table 2



Fitzgibbons Copper-Steel Heating Boiler for small-sized installations, homes, churches, garages, etc.

rear gas-deflecting arch diverts the gases forward into intimate mixture with the preheated secondary air which enters through a port above the firing door. As the air-gas mixture whirls upward combustion is completed before the gases enter the tubes, resulting in very high furnace temperatures,—often close to 3000 deg. fahr. Smokeless combustion of semi-bituminous coal indicates the thoroness of this combustion.

Conduction and Circulation: The absorption of the heat so effectively generated in the Fitzgibbons furnace is accomplished by the unique design of this time-proved Boiler. The water line is carried in the vertical shell directly above the combustion chamber, the horizontal tube Cylinder being completely filled with water. Therefore the circulation of the water is extremely rapid as the boiler steams and the bubbles move along fixed paths toward the steam chamber. This rapid circulation insures heat absorption as effective as the heat generation accomplished in the furnace as is evidenced by (1) the quick-steaming capacity, (2) less than 1 per cent moisture in steam regardless of overload carried, and (3) unusually low flue-gas temperatures.

Detailed Information will be mailed promptly upon request.

TABLES 1 AND 1-B COMBINED—FITZGIBBONS STEEL HEATING & SMOKELESS HEATING BOILERS
Double-Electric-Welded Furnaces
Sizes 300 to 3200 sq. ft. Steam Rating—Built for 15 lb. w.s.p.—A.S.M.E. Code

No. of Boiler	J-6	J-8	H-8	J-10	J-12	H-16	H-20	H-24	H-28	H-32	H-36	H-44	H-50	H-58	H-64
No. of Smokeless Boiler	None	None	B-8	B-10	B-12	B-16	B-20	B-24	B-28	B-32	B-36	B-44	B-50	B-58	B-64
Steam Rating....sq. ft.	300	400	400	500	600	800	1000	1200	1400	1600	1800	2200	2500	2900	3200
Hot Water Rating...sq. ft.	500	700	700	800	1000	1300	1600	1900	2200	2600	2900	3500	4000	4600	5100
Heating Surface....sq. ft.	30	33	35	43	51	67	78	95	108	123	150	192	233	249	295
*Comp. Grate Area...sq. ft.	2.5	2.5	3.36	3.36	3.36	4.35	4.35	5.84	5.84	7.10	7.10	8.50	8.50	10.00	10.00
Diam. Vertical Shell...in.	23	23	26	26	26	29	29	33	33	37	37	40	40	43	43
Length Bare Boiler..ft. in.	3-3	3-3	3-9	4-1	4-5	4-9	5-3	5-8	6-2	6-9	7-9	7-7	8-7	8-4	9-4
Diam. Horizontal Shell..in.	18	18	18	18	18	21	21	23	23	27	27	31	31	33	33
Water Line.....ft. in.	3-5	3-5	3-7	3-7	3-7	4-0	4-0	4-4	4-4	4-7	4-7	4-11	4-11	5-2	5-2
Diameter Base.....in.	26½	26½	30	30	30	33½	33½	37½	37½	40½	40½	42¾	42¾	45¾	45¾
Fire Door Center.....in.	25½	25½	27	27	27	31	31	31	31	31	31	31	31	31	31
Overall Height.....ft. in.	4-2	4-2	4-3	4-3	4-3	4-8	4-8	5-0	5-0	5-5	5-5	5-9	5-9	6-1	6-1
Width of Uptake.....in.	5½	5½	5½	5½	5½	6½	6½	7½	7½	8½	8½	9½	9½	10	10
Length of Uptake.....in.	12½	12½	12½	12½	12½	15½	15½	17½	17½	20½	20½	22	22	25	25
Tube Space.....in.	18	18	18	18	22	24	30	27	32	31	43	35	47	40	52
Grate Diameter.....in.	19	19	22	22	22	25	25	29	29	32	32	35	35	38	38
Stack Diameter.....in.	8	8	8	8	8	10	10	12	12	14	14	16	16	18	18
Stack Height.....ft.	35	40	40	45	45	40	45	45	45	50	50	50	60	60	60
Shipping Weight.....lbs.	900	920	1150	1175	1225	1525	1625	2000	2100	2400	2460	3000	3200	3550	3800

TABLE 2—FITZGIBBONS STEEL HEATING BOILERS
Double-Electric-Welded Furnaces
Sizes 3800 to 19000 sq. ft. Steam Rating—Built for 15 lb. w.s.p.—A.S.M.E. Code

No. of Boiler	H-76	H-86	H-98	H-108	H-120	H-132	H-144	H-160	H-170	H-200	H-220	H-250	H-270	H-310	H-330	H-360	H-380
Steam Rating.....sq. ft.	3800	4300	4900	5400	6000	6600	7200	8000	8500	10000	11000	12500	13500	15500	16500	18000	19000
Hot Water Rating...sq. ft.	6000	6900	7900	8700	9600	11000	12000	13500	14500	16000	17500	20000	21500	25000	26500	29000	30500
Heating Surface.....sq. ft.	354	393	397	428	497	582	665	674	772	826	920	1048	1109	1308	1372	1511	1571
*Comp. Grate Area...sq. ft.	12.8	12.8	15.4	15.4	18.8	18.8	18.8	21.0	21.0	24.2	24.2	29.4	29.4	32.0	32.0	36.0	36.0
Diam. Vert. Shell....ft. in.	4-0	4-0	4-4	4-4	4-9	4-9	4-9	5-0	5-0	5-4	5-4	5-10	5-10	6-2	6-2	6-6	6 6
Length Bare Boiler...ft. in.	9-1	10-1	9-7	10-7	9-9	10-9	11-9	10-10	11-10	11-10	12-10	12-2	12-8	14-0	14-6	14-3	15-2
Diam. Horiz. Shell...ft. in.	3-4	3-4	3-6	3-6	4-0	4-0	4-0	4-3	4-3	4-6	4-6	5-0	5-0	5-2	5-2	5-6	5-6
Water Line.....ft. in.	6-0	6-0	6-0	6-0	6-7	6-7	6-7	6-11	6-11	8-3	8-3	8-9	8-9	8-11	8-11	9-6	9-6
Overall Height.....ft. in.	7-1	7-1	7-2	7-2	7-10	7-10	7-10	8-2	8-2	9-5	9-5	10-0	10-0	10-2	10-2	11-0	11-0
Smoke Uptake.....in. x in.	13½x26	13½x26	14x27	14x27	14x37	14x37	14x37	14x44	14x44	15x49	15x49	16x58	16x58	17x58	17x58	18x63	18x63
Tube Space.....ft. in.	3-10	4-10	3-9	4-9	3-9	4-9	5-9	4-9	5-9	6-7	7-7	6-6	7-0	7-10	8-4	7-9	8-8
Grate Diameter.....in.	43	43	47	47	52	52	52	55	55	59	59	65	65	68	68	72	72
Stack Diameter.....in.	20	22	22	22	24	24	24	26	26	28	30	30	30	32	32	34	34
Stack Height.....ft.	60	65	65	70	70	70	80	80	80	80	80	85	85	100	100	125	125
Shipping Weight.....lbs.	5250	6100	6650	7400	9000	9500	10000	10500	11000	13000	13800	15200	16000	18400	19000	19500	20500

TABLE 3—FITZGIBBONS STEEL HEATING AND POWER BOILERS
All-Riveted Construction—A.S.M.E. Code
Sizes 4200 to 36000 sq. ft. Steam Rating—Heating Boilers Built for 15 lb. w.s.p.
Power Boilers, for Kitchen, Laundry, Drying, Process and Similar
High-Pressure Loads, Built for 100 lb. w.s.p.

No. of Boiler	23	24	25	26	27	29	30	31	32	33	34	35	36	37
Horse Power	40	50	60	70	80	100	125	150	175	200	225	250	300	350
Steam Rating.....sq. ft.	4200	5400	6400	7500	8500	11000	13500	16500	19000	22000	25000	28000	32000	36000
Hot Water Rating.....sq. ft.	6700	8700	10500	12000	14500	17500	21500	26500	30500	35000	40000	45000	51000	58000
Heating Surface.....sq. ft.	380	456	547	631	721	917	1147	1350	1571	1823	2012	2271	2760	3220
*Comparative Grate Area.....sq. ft.	13.2	15.3	17.4	18.8	21.0	24.2	29.4	33.0	36.0	38.1	40.2	44.5	50.2	57.5
Diameter Vertical Shell.....ft. in.	4-1	4-5	4-8	4-10	5-1	5-5	5-11	6-3	6-7	6-9	6-11	7-3	7-8	8-4
Height Overall.....ft. in.	8-6	8-9	9-2	9-5	9-9	10-1	10-8	11-0	11-11	12-1	12-2	12-6	13-0	13-6
Length Bare Boiler.....ft. in.	9-4	10-6	10-9	12-2	12-3	13-7	13-11	15-1	15-4	16-2	17-5	18-2	19-2	19-6
Diameter Horizontal Shell.....ft. in.	3-5	3-8	3-11	4-1	4-4	4-7	5-1	5-3	5-7	5-9	5-9	6-1	6-6	7-1
Smoke Uptake.....in. x in.	12x24	12x31	13x36	13x42	13x48	14½x49	15½x58	17x58	18x62½	19x65	19x65	20x68	24x73	24x80
Space to Draw Tubes.....ft. in.	4-8	5-7	5-6	6-10	6-10	7-9	7-8	8-6	8-4	8-10	10-0	10-5	11-0	11-0
Water Line.....ft. in.	7-1	7-4	7-8	7-11	8-2	8-5	8-11	9-1	9-10	10-1	10-1	10-5	11-4	11-10
Grate Diameter.....in.	43	47	50	52	55	59	65	68	72	74	76	80	85	91
Stack Diameter.....in.	22	22	24	24	26	28	30	32	34	34	38	40	48	48
Stack Height.....ft.	65	70	70	70	80	80	90	100	125	140	140	140	165	190
Shipping Weight.....lbs.	7500	9500	10000	11500	12000	15200	18000	20000	23000	26000	29000	32000	37000	44000

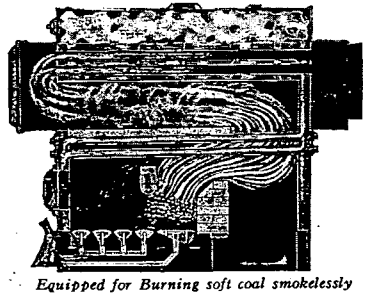
*It has been established that the Circular Grate *in the Fitzgibbons Cylindrical Furnace* is more effective than a rectangular grate the size of the circumscribed square. Hence, for comparative purposes, the **Comparative Grate Area** shown in the Tables is the area of the square circumscribed upon a circle the size of the Fitzgibbons Grate.

The Frost Manufacturing Co.

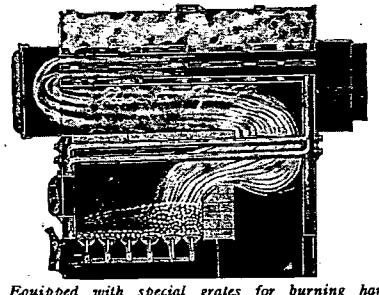
Ross Steel Heating Boilers

1530 Henderson Street

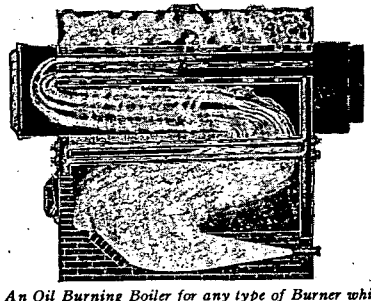
Galesburg, Ill.



Equipped for Burning soft coal smokelessly



Equipped with special grates for burning hard coal, soft coal, wood or sawdust



An Oil Burning Boiler for any type of Burner which can be installed in either front or rear of boiler

ROSS STEEL BOILERS

Steam or Hot Water

Designed for use with Bituminous, Anthracite, Buckwheat Coal, Gas, Oil, Wood or Sawdust.

Ross Boilers are quality Boilers built of steel to comply with the *A. S. M. E.* Code for heating boilers. All seams are electrically welded. Ross Boilers have unusual strength as they have no seams in tension.

Some points of advantage in Ross Boilers:

1. Spacious fire box and combustion chamber.
2. Long three pass travel of fire.
3. Fire box surfaces with crown sheet and bank of water tubes present unusually large amount of radiant heating surface in high temperature zone.
4. Complete, rapid and unrestricted circulation of water accelerated by water tubes.
5. Ample heating surface and grate surface in proper ratios.
6. Large central flue to allow complete combustion.
7. Liberal steam space and releasing area.
8. Unrestricted draft areas, correctly proportioned.
9. Large water content for hold-over.
10. Indestructible smokeless arch.
11. Full length self-cleaning crown sheet.
12. Every water space easily accessible for cleaning and inspection.
13. All tubes cleaned from outside of boiler at front.
14. Standardization of parts.
15. Perforated angle on base for securely lacing on covering.

Ross Boilers are quick, economical steamers, built for heavy duty and to outlast the building. They occupy but limited floor space, but are made big enough to carry a large body of water with broad steam disengaging areas and large combustion spaces.

SPECIFICATIONS—ROSS STEEL FIREBOX HEATING BOILERS

Built to Comply with *The American Society of Mechanical Engineers* Code for Low Pressure Heating Boilers

STEAM BOILER		BOILER DIMENSIONS				Heating Surface Sq. Ft.	Grate Surface Sq. Ft.	Diameter Smoke Breeching		SMOKESTACKS				STEAM OPENINGS		Weight Approx. Lb.	Insulating Covering Required Sq. Ft.	WATER BOILER	
										One Boiler		Two Boilers							
No.	Rating Sq. Ft.	Diam. In.	Length In.	Height In.	Water Line In.			One Boiler In.	Two Boilers In.	Diam. In.	Height Ft.	Diam. In.	Height Ft.	Main In.	Return In.			Rating Sq. Ft.	No.
S104	800	30	45	67	55	77	3.96	12		12	40			3½	2½	2000	45	1280	W104
S105	950	30	51	67	55	90	4.98	12		12	40			4	2½	2200	55	1500	W105
S106	1100	30	57	67	55	103	5.98	12		12	40			4	3	2500	57	1760	W106
S107	1300	30	63	67	55	117	6.18	14		12	40			5	3	2800	63	2080	W107
S108	1700	30	69	69	58	145	7.15	14		12	50			5	3	3200	65	2700	W108
S109	2000	30	75	69	58	157	8.15	14		12	50			5	3	3600	75	3200	W109
S110	2500	34	83	72	61	197	9.34	16	24	14	60	22	65	5	3	4150	85	4000	W110
S111	3000	34	95	72	61	235	9.34	16	24	14	60	22	65	5	3	4500	95	4800	W111
S112	3600	34	107	72	61	270	10.50	16	24	14	60	22	65	6	3½	5000	106	5750	W112
S113	4300	44	93	78	66	324	11.22	22	30	20	60	26	65	6	3½	6400	107	6900	W113
S114	5000	44	105	78	66	372	12.80	22	30	20	60	26	65	6	3½	7100	120	8000	W114
S115	5700	44	117	78	66	419	14.38	22	30	20	60	26	65	6	3½	7900	133	9000	W115
S116	6400	48	109	86	71½	469	15.92	24	34	22	65	32	70	6	3½	8600	127	10200	W116
S117	7200	48	121	86	71½	533	17.65	24	34	22	65	32	70	6	3½	9600	139	11500	W117
S118	8000	54	111	98	79	571	18.16	26	38	24	65	34	70	8	5	10400	140	12800	W118
S119	9000	54	123	98	79	649	20.17	26	38	24	65	34	70	8	5	11100	156	14500	W119
S120	10000	64	117	102	83½	732	21.95	28	40	26	70	36	75	8	5	13000	172	16000	W120
S121	11000	64	129	102	83½	825	24.33	28	40	26	70	36	75	8	5	14700	192	17600	W121
S122	12500	64	140	102	83½	917	26.73	28	40	26	70	36	75	8	5	15500	212	20000	W122
S123	14500	68	137	109	90½	1045	28.36	32	46	30	70	42	75	8	5	18300	230	23200	W123
S124	16000	68	149	109	90½	1156	30.94	32	46	30	75	42	80	8	5	19600	248	25600	W124
S125	17500	68	161	109	90½	1267	30.94	32	46	30	75	42	80	8	5	21000	265	28000	W125
S126	20000	78	159	122	96½	1366	33.00	36	50	32	80	44	90	8	5	23600	258	32000	W126
S127	22000	78	171	122	96½	1496	36.00	36	52	34	90	46	100	8	5	24800	283	35000	W127
S128	24500	78	165	125	102½	1632	39.00	36	52	34	90	46	100	8	6	25300	268	39000	W128
S129	27500	78	177	125	102½	1783	39.00	36	52	34	90	46	100	10	6	26700	294	44000	W129
S130	30000	84	165	132	109½	1946	42.32	40	56	38	100	48	110	10	6	29800	304	48000	W130
S131	32000	84	171	132	109½	2036	42.32	40	56	38	100	48	110	10	6	31300	316	51000	W131
S132	35000	84	183	132	109½	2215	45.50	40	56	38	100	50	110	10	6	34800	340	56000	W132

Every Boiler Inspected by the Hartford Insurance Co. Certificate of Inspection Furnished *Catalogue Sent on Request*

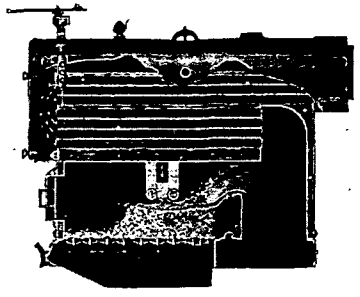
Heggie-Simplex Boiler Co.

Joliet, Illinois

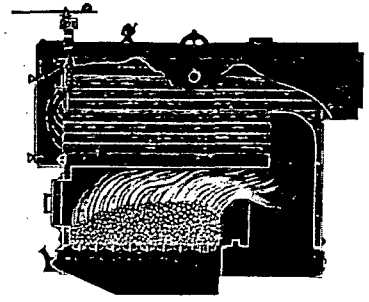
Heating Boiler Division of James G. Heggie & Sons, Manufacturers of Steel Boilers of all Kinds for over Thirty-seven Years

Representatives in Principal Cities

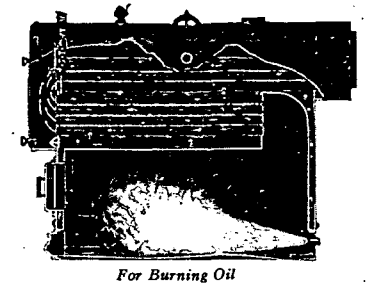
HEGGIE-SIMPLEX HEATING BOILERS



For Burning Soft Coal Smokelessly



For Soft or Hard Coal, Coke, Gas or Wood



For Burning Oil

During the thirty-seven years covered by the activities of Jas. G. Heggie & Sons, boiler design has been perfected in its fundamentals. The Heggie-Simplex Boiler is the last step in this evolution. In it there is no compromise with traditional features. It is the embodiment of a scientific study of all known heating principles and requirements.

The Heggie-Simplex Boiler combines in one portable, electrically welded steel unit all the recognized advantages of both firebox and return tubular, double pass boilers. It has four distinctive features of fundamental importance:

1. An extra large firebox and a *maximum* of *direct* heating surface.
2. A secondary combustion chamber that provides ample room for complete combustion before the flues are reached.
3. A "rear-front-rear" flue passage for the gases.
4. A single, unimpeded, freely circulating body of water.

Correct heating principles find perfect expression in this boiler design. It secures as complete combustion of any fuel as ever has been attained in a heating boiler, with full application of its heat units.

Needless to say, Heggie-Simplex Boilers are more economical of operation than other types—in fuel consumption, number of firings, and ash handling. They are also economical of space, because of their compactness, the rear smoke outlet, and the front tube cleaning feature. No finer materials are used in any heating boilers, and none are fabricated more expertly or with greater care. While built to *A. S. M. E.* requirements, in a number of points they exceed these standards. They may be installed with unexampled ease, requiring no bricking, packing or other costly operations.

Heggie-Simplex Boilers are guaranteed to develop the capacities listed on the following pages, at the point of most economical fuel consumption. They are based upon a standard for steam of two pounds pressure at the boiler, and for water upon a mean temperature of 180 deg. fahr. as the water leaves the boiler.

Send for catalog to obtain more detailed information and specifications.

HEGGIE-SIMPLEX HEATING BOILERS—STEAM AND WATER

Number of Boiler—Steam, Direct Draft	3341	3342	3343	3401	3402	3403	3404	3471	3472	3473	3521	3522	3523	3571	3572															
Number of Boiler—Steam, Smokeless	1341	1342	1343	1401	1402	1403	1404	1471	1472	1473	1521	1522	1523	1571	1572															
Capacity, Steam sq. ft.	1700	2000	2300	3000	3500	4000	4500	5000	5800	6000	6500	7000	7500	8000	9000															
Number of Boiler—Water, Direct Draft	4341	4342	4343	4401	4402	4403	4404	4471	4472	4473	4521	4522	4523	4571	4572															
Number of Boiler—Water, Smokeless	2341	2342	2343	2401	2402	2403	2404	2471	2472	2473	2521	2522	2523	2571	2572															
Capacity, Water sq. ft.	2800	3300	3800	5000	5800	6600	7400	8200	9000	9800	10700	11500	12300	13200	14800															
Heating Surface sq. ft.	142	158	189	254	278	302	325	372	431	461	479	514	550	634	678															
Grate Area sq. ft.	6.5	7.8	9.1	10.7	12.2	13.7	15.2	14.7	18.4	20.2	18.6	20.7	22.7	22.9	22.9															
Height of Water Line in.	62¼	62¼	62¼	69	69	69	69	72½	72½	72½	78½	78½	78½	81	81															
Height of Boiler in.	72	72	72	79	79	79	79	86	86	86	91	91	91	97	97															
Width of Boiler in.	34	34	34	40	40	40	40	47	47	47	52	52	52	57	57															
Length of Boiler in.	74	80	92	93	99	105	102	114	120	120	104	110	116	110	116															
Diameter of Breeching in.	20	20	22	22	22	22	24	24	24	24	26	26	26	28	28															
Diameter of Stack in.	18	18	18	20	20	20	22	22	22	22	24	24	24	26	26															
Minimum Height of Stack ft.	55	55	55	60	60	60	60	65	65	65	70	70	70	75	75															
Diameter of Breeching—2 Boilers in.	28	28	28	30	30	30	30	34	34	34	38	38	38	40	40															
Diameter of Stack—2 Boilers in.	26	26	26	28	28	28	28	32	32	32	34	34	34	36	36															
Minimum Height of Stack—2 Boilers ft.	65	65	65	70	70	70	70	75	75	75	80	80	80	85	85															
Size of Outlet, Steam Boilers in.	6	6	6	6	6	6	6	8	8	8	8	8	8	8	8															
Size of Return, Steam Boilers in.	3	3	3	3	3	3	3	4	4	4	4	4	4	4	4															
Number of Safety Valves	—	—	—	—	—	—	—	—	1	1	1	1	1	1	1															
Size of Safety Valves in.	1½	1½	1½	2	2	2	2½	2½	2½	3	3	3	3	3	3															
Boiler Covering Required sq. ft.	72	78	89½	98	104	110	116	125	141	149	136	144	152	158	167															
Supply Outlets and Return Openings on Water Boilers—as specified on contractor's order, in sizes 3, 4, 5, 6, 8 or 10 in.																														
Number of Boiler—Steam, Direct Draft	3573	3574	3631	3632	3633	3701	3702	3703	3704	3781	3782	3841	3842	3843	3844															
Number of Boiler—Steam, Smokeless	1573	1574	1631	1632	1633	1701	1702	1703	1704	1781	1782	1841	1842	1843	1844															
Capacity, Steam sq. ft.	10000	11000	12000	13000	14000	15000	16000	17000	18500	20000	22000	25000	28000	31000	34000															
Number of Boiler—Water, Direct Draft	4573	4574	4631	4632	4633	4701	4702	4703	4704	4781	4782	4841	4842	4843	4844															
Number of Boiler—Water, Smokeless	2573	2574	2631	2632	2633	2701	2702	2703	2704	2781	2782	2841	2842	2843	2844															
Capacity, Water sq. ft.	16400	18000	19800	21400	23000	25000	26600	28200	30600	32800	36000	41000	46000	51000	56000															
Heating Surface sq. ft.	766	810	859	922	1047	1094	1166	1238	1382	1484	1646	1911	2110	2309	2502															
Grate Area sq. ft.	25.2	25.2	25.5	28.1	28.1	28.2	31.0	31.0	33.9	38.2	38.2	38.0	41.3	44.8	44.8															
Height of Water Line in.	81	81	92¾	92¾	92¾	96	96	96	96	104¾	104¾	111¼	111¼	111¼	111¼															
Height of Boiler in.	97	97	108	108	108	116	116	116	116	126	126	132	132	132	132															
Width of Boiler in.	57	57	63	63	63	70	70	70	70	78	78	84	84	84	84															
Length of Boiler in.	128	134	118	124	136	124	130	136	148	148	160	154	166	178	190															
Diameter of Breeching in.	28	28	30	30	30	34	34	34	38	38	38	42	42	42	42															
Diameter of Stack in.	26	26	28	28	28	32	32	32	36	36	36	40	40	40	40															
Minimum Height of Stack ft.	75	75	75	75	80	80	80	80	90	90	90	100	100	100	125															
Diameter of Breeching—2 Boilers in.	40	40	44	44	44	46	46	46	50	54	54	54	56	56	56															
Diameter of Stack—2 Boilers in.	36	36	40	40	40	46	46	46	50	54	54	54	54	54	54															
Minimum Height of Stack—2 Boilers ft.	85	85	85	85	85	90	90	90	100	100	100	110	110	110	125															
Size of Outlet, Steam Boilers in.	8	8	10	10	10	10	10	10	10	10	10	10	10	10	10															
Size of Return, Steam Boilers in.	4	4	5	5	5	5	5	5	5	5	5	5	5	5	5															
Number of Safety Valves	2	2	2	2	2	2	2	2	2	2	2	2	2	3	3															
Size of Safety Valves in.	2	2	2	2	2	2	2	2	2	2	2	2	2½	2½	3															
Boiler Covering Required sq. ft.	184	193	188	197	215	220	230	240	260	281	304	314	337	361	390															

Supply Outlets and Return Openings on Water Boilers—as specified on contractor's order, in sizes 3, 4, 5, 6, 8 or 10 in.
Maximum Working Pressure, Steam Boilers, 15 lb.; Water Boilers, 30 lb., 100 lb. and 160 lb.

Herbert Boiler Company

INCORPORATED

Factory and General Offices

Root and La Salle Streets **Chicago, Illinois**

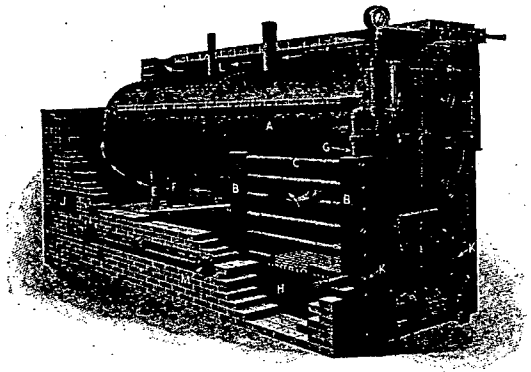
Products made by the HERBERT BOILER CO. consist of HERBERT Steel Heating and Power Boilers, HERBERT Garbage Burning Water Heaters and HERBERT Tank Heaters.

Important features of HERBERT Boiler design and construction are the long fire travel with consequent fuel economy, the double combustion feature which is particularly advantageous for oil burning, the detachable fire-box eliminating expensive alterations and the rugged construction which is in accordance with *A.S.M.E.* Boiler Code.

Some of the finest buildings in the United States and Canada are heated by HERBERT detachable fire-box boilers because of their ability to make steam efficiently with a minimum of fuel. They are approved by all boiler inspection and insurance companies.

Among other points of superiority are the increased capacity of the tubular by as much as 25 per cent because of the additional fire-box surface.

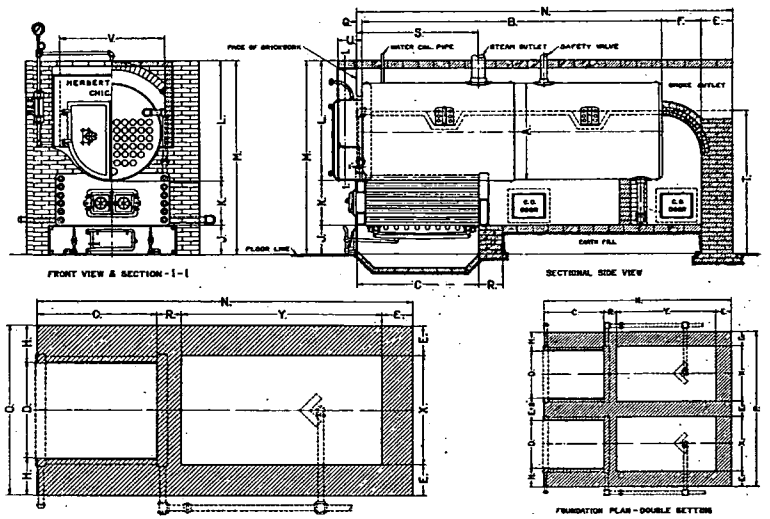
Every inch is fire surface—the flame passing over the entire shell and back head of the boiler before entering the chimney.



A–*Tubular Boiler.*
BB–*Steel Water Legs.*
C–*"X Heavy" Water Tubes.*
E–*Return Connection.*
F–*Boiler Stand.*
GG–*Genuine Wrought Iron Circulating Pipes.*
H–*Ashpit.*
J–*Clean-out Door.*
KK–*Clean-out Plugs.*
L–*Smoke Travel.*
M–*Connection for Blow-off.*

SPECIFICATIONS A. S. M. E. Code Construction

Number of Boiler	Diameter—Inches	Length—Feet	Size of Firebox—Inches	Size of Plugs—Inches	Number of Plugs	Tappings—Inches	Rating, Steam—Square Feet	Rating, Water—Square Feet	Shipping Weight—Lbs.	Height to Water Line—Inches	Height to Top of Boiler—Inches
C 1	24	4	24x26	3	18	3–2	950	1500	1700	58	62
C 2	24	5	24x26	3	18	3–2	1100	1800	1900	58	62
C 3	24	6	24x32	3	18	3–2	1400	2200	2100	58	62
B 0	30	6	30x32	3	24	4–2	1800	2900	3500	61	68
B 1	30	8	30x38	3	24	4–2½	2300	3700	3800	61	68
B 2	30	10	30x44	3	24	4–2½	2800	4500	4200	61	68
B 2½	36	8	36x38	3	30	4–2½	3000	4800	4500	67	75½
B 3	36	10	36x44	3	30	4–2½	3600	5800	5000	67	75½
B 4	36	12	36x50	3½	28	5–3	4300	6900	5400	67	75½
B 5	36	14	36x56	3½	28	5–3	5000	8000	6200	67	75½
B 6	42	12	42x50	3½	34	5–3	5400	8600	6800	70	81½
B 7	42	14	42x56	3½	34	6–3	6300	10100	7600	70	81½
B 8	48	12	48x50	3½	42	6–3	6600	10600	8200	73	87½
B 9	48	14	48x56	3½	42	6–3	7600	12200	9300	73	87½
B10	48	16	48x62	3½	42	7–4	8700	13900	10000	73	87½
B11	54	12	54x56	3½	54	7–4	8700	13900	11000	79½	96
B12	54	14	54x62	3½	54	7–4	10000	16000	12600	79½	96
B13	54	16	54x68	4	49	7–4	11500	18400	13300	79½	96
B14	60	14	60x62	3½	64	8–4	12500	20000	14500	86	105
B15	60	16	60x68	4	54	8–4	13500	21600	15700	86	105
B16	66	16	66x68	4	64	8–4	15800	25300	17900	92	112½
B17	66	18	66x74	4	64	10–5	17700	28300	19200	92	112½
B18	72	16	72x68	4	80	10–5	19000	30400	22000	95	118½
B19	72	18	72x74	4	80	10–5	20600	33000	23500	95	118½



Setting Measurements, Herbert "B" Series Boilers

	NUMBER OF BOILER	C-1	C-2	C-3	B-0	B-1	B-2	B-2½	B-3	B-4	B-5	B-6	B-7	B-8	B-9	B-10	B-11	B-12	B-13	B-14	B-15	B-16	B-17	B-18	B-19
A	Diameter Boiler	24"	24"	24"	30"	30"	30"	36"	36"	36"	36"	42"	42"	48"	48"	48"	54"	54"	54"	60"	60"	66"	66"	72"	72"
B	Length of Boiler	4'0"	5'0"	6'0"	6'0"	8'0"	10'0"	8'0"	10'0"	12'0"	14'0"	12'0"	14'0"	12'0"	14'0"	16'0"	12'0"	14'0"	16'0"	14'0"	16'0"	16'0"	18'0"	16'0"	18'0"
C	Length of Firebox	35"	35"	35"	35"	35"	44"	35"	44"	50"	56"	50"	56"	50"	56"	62"	56"	62"	68"	62"	68"	68"	74"	68"	74"
D	Width of Firebox	24"	24"	24"	30"	30"	30"	36"	36"	36"	36"	42"	42"	48"	48"	48"	54"	54"	54"	60"	60"	66"	66"	72"	72"
E	Thickness of Walls	9"	9"	9"	9"	9"	9"	9"	13"	13"	13"	13"	13"	13"	13"	13"	13"	13"	13"	17"	17"	17"	17"	17"	17"
F	Space at Rear	14"	14"	14"	18"	18"	18"	18"	18"	18"	18"	18"	18"	22"	22"	22"	22"	22"	22"	22"	22"	26".	26"	26"	26"
G	Distance at Front	1½"	1½"	1½"	1½"	1½"	1½"	8"	2"	2"	2"	2"	2"	2"	2"	2"	2"	2"	2"	2"	2"	2"	2"	2"	2"
H	Wall Thickness at Ashpit	13"	13"	13"	13"	13"	13"	17"	17"	17"	17"	17"	17"	17"	17"	17"	21"	21"	21"	21"	21"	21"	21"	25"	25"
J	Height of Ashpit Casting	13½"	13½"	13½"	13½"	13½"	13½"	13½"	15"	15"	15"	15"	15"	15"	15"	15"	15"	15"	15"	15"	15"	16½"	16½"	16½"	16½"
K	Height of Firebox	24"	24"	24"	24"	24"	24"	24"	24"	24"	24"	24"	24"	24"	24"	24"	24"	24"	24"	24"	24"	27"	27"	27"	27"
L	Ht. of Boiler Shell & Covering	30"	30"	30"	42"	42"	42"	42"	42"	42"	42"	48"	48"	54"	54"	54"	60"	60"	60"	66"	66"	72"	72"	78"	78"
M	Height Overall	6'3"	6'3"	6'3"	6'10"	6'10"	6'10"	7'0"	7'0"	7'0"	7'0"	7'0"	7'0"	8'0"	8'0"	8'0"	8'0"	8'0"	8'0"	9'3"	9'3"	9'3"	9'3"	9'11"	9'11"
N	Length Overall	6'8"	7'8"	8'8"	8'4"	10'4"	12'4"	10'8"	12'8"	14'8"	16'8"	14'10"	16'10"	15'2"	17'2"	19'2"	15'2"	17'2"	19'2"	17'0"	19'0"	19'0"	21'0"	20'0"	22'0"
O	Width Single Setting	4'4"	4'4"	4'4"	4'8"	4'8"	4'8"	5'10"	5'10"	5'10"	5'10"	6'4"	6'4"	6'10"	6'10"	6'10"	7'4"	7'4"	7'4"	8'0"	8'0"	8'	9'	9'	9'6"
P	Width Double Setting	8'3"	8'3"	8'3"	8'11"	8'11"	8'11"	10'7"	10'7"	10'7"	10'7"	11'7"	11'7"	13'11"	13'11"	13'11"	13'11"	13'11"	13'11"	15'11"	15'11"	16'11"	16'11"	18'10"	18'10"
R	Bridge Wall Thickness	9"	9"	9"	9"	9"	9"	9"	9"	9"	9"	9"	9"	9"	9"	9"	9"	9"	9"	13"	13"	13"	13"	13"	13"
S	Stm. Outlet from Face of Boiler	20"	24"	27"	27"	25"	41"	25"	40"	52"	62"	53"	63"	52"	62"	70"	53"	62"	70"	62"	70"	70"	78"	68"	76"
T	Height of Shell	58"	58"	58"	61"	61"	61"	67"	67"	67"	67"	70"	70"	73"	73"	73"	79½"	79½"	79½"	80"	80"	92"	92"	95"	95"
U	Smoke Uptake Width	8"	8"	8"	8"	8"	8"	9"	9"	9"	9"	11"	11"	13"	13"	13"	13"	13"	13"	14"	14"	16"	16"	17"	17"
V	Smoke Uptake Length	54"	54"	54"	57"	57"	57"	57"	57"	57"	57"	60"	60"	63"	63"	63"	63"	54"	54"	60"	60"	60"	60"	73"	73"
X	Inside Width	20"	20"	20"	26"	26"	26"	42"	42"	42"	42"	48"	48"	54"	54"	54"	60"	60"	60"	66"	66"	72"	72"	78"	78"
Y	Inside Length	8'2"	8'2"	8'2"	8'8"	8'10"	8'4"	8'10"	8'8"	8'11"	8'8"	8'11"	8'8"	10'0"	10'0"	10'0"	11'10"	8'0"	8'0"	11'0"	11'0"	11'2"	11'2"	13'8"	13'8"

Proper circulation between the back end of the boiler and the fire-box produces quick steaming. All parts accessible for cleaning with arrangements so that flues can be cleaned without opening fire doors as this is accomplished from the front. Boiler can be set in any position regardless of chimney position.

No bridge wall in fire-box and no fire brick lining to install or replace.

Detachable fire-box feature permits renewal of fire-box without moving tubular boiler or destroying the setting.

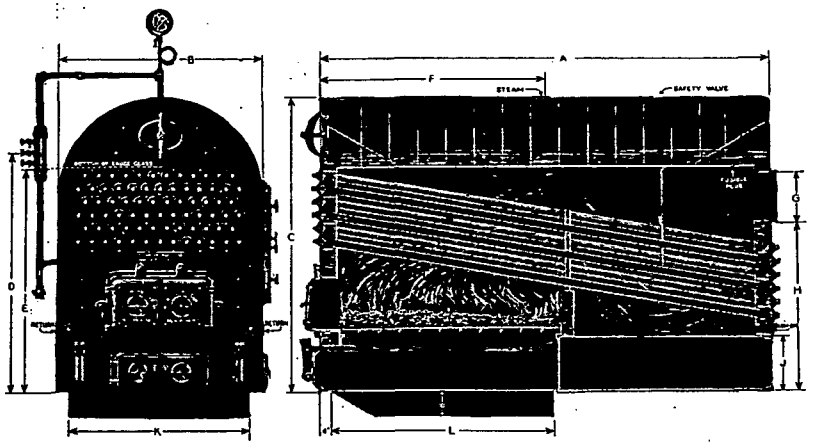
Accompanying data gives complete information about HERBERT Detachable Fire-Box Boiler *B* Series.

Harrisburg Star Boiler Corporation

15 Park Row, New York

LOW PRESSURE WATER TUBE HEATING BOILERS

A.S.M.E. Code



Standard Equipment consists of Shaking and Dumping Grates, Steel Base, Low Pressure Steam Gage with Siphon, Cast Iron Water Column with gage glass and three brass try-cocks, Pop Safety Valves as required, Cleaning Brush, Tube Scraper, Hoe, Poker and Slice Bar.

(Boilers Nos. 704 to 718 inclusive, require no brick work of any kind. Boilers Nos. 719 to 725 inclusive, require brick bridgewalls.)

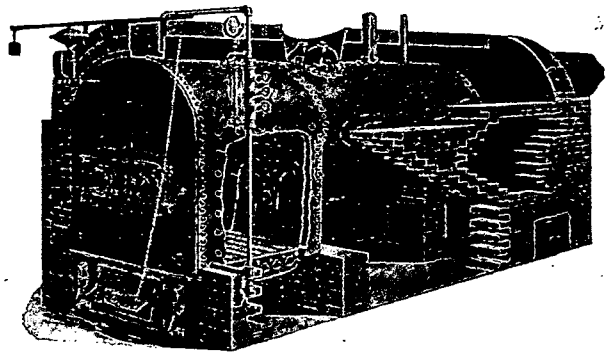
Boiler Number	Steam, Capacity, Sq. Ft.	Water Evaporation, Lbs.	Grate Surface, Sq. Ft.	"A" Total Length, Ft.	"B" Total Width, In.	"C" Total Height, Ft.	"D" Water Line, In.	"C" Size Smoke Flue	"J" Height of Base	"K" Width Ash Pit	"L" Length Ash Pit	Diameter Stack One Boiler, In.	Height Stack One Boiler, Ft.	Diameter Stack Two Boilers, In.	Height Stack Two Boilers, Ft.	Brick Required for Base	Asbestos Cover, Sq. Ft.	Approx. Weight Boiler Complete
704	2750	690	9.4	7-9	39	5-5	56	10x26	15	2-8	3-8	18	50	23	50	None	76	5500
705	3450	862	10.6	7-0	43	6-0	61	13x22	15	3-0	3-8	18	50	24	50	"	77	6800
706	4150	1035	12.1	8-3	43	6-0	61	13x28	15	3-0	4-2	18	60	25	60	"	91	7300
707	5000	1242	14.8	8-3	52	6-4	63	13x31	15	3-8	4-2	20	60	27	60	"	99	8000
708	5800	1449	14.8	8-3	52	6-7	66	13x31	15	3-8	4-2	21	60	29	65	"	103	9000
709	6900	1725	18.3	9-1	56	6-8	68	13x38	15	4-0	4-8	23	60	31	65	"	118	10700
710	8300	2070	20.3	10-10	56	6-8	68	13x42	15	4-0	5-2	25	60	33	70	"	141	11300
711	9000	2242	21.8	10-10	60	6-11	69	16x36	15	4-4	5-2	25	65	34	70	"	148	11700
712	9700	2415	24.0	11-7	60	6-11	69	16x39	15	4-4	5-8	26	65	35	70	"	160	12000
713	10400	2587	26.2	12-5	60	6-11	69	16x43	15	4-4	6-2	26	65	36	70	"	171	12500
713A	11000	2760	26.2	11-7	60	7-3	73	19x36	15	4-4	6-2	27	70	36	75	"	167	12800
714	11700	2932	28.3	12-6	60	7-3	73	19x39	15	4-4	6-8	28	70	37	75	"	178	13300
715	12400	3105	30.5	13-1	60	7-3	73	19x42	15	4-4	7-2	29	70	38	75	"	188	14000
716	13800	3450	31.8	11-10	71	7-11	76	19x43	15	5-3	6-3	30	70	40	80	"	193	15500
717	15200	3795	34.4	12-11	71	7-11	76	19x47	15	5-3	6-9	31	70	42	80	"	208	16800
718	17300	4312	37.0	14-7	71	7-11	76	19x50	15	5-3	7-3	32	80	43	90	"	234	18500
719	18600	4657	41.3	12-6	90	9-1	83	21x46	18	6-10	6-3	33	85	44	90	"	244	20000
720	20700	5175	44.7	13-10	90	9-1	83	21x51	18	6-10	6-9	34	90	46	100	"	260	21000
721	24200	6037	51.0	16-1	90	9-1	83	21x61	18	6-10	7-9	36	100	48	110	"	304	25200
722	27600	6900	55.4	14-1	103	10-2	90	21x66	18	7-11	7-3	38	100	51	110	"	302	27700
723	31600	7762	55.4	14-1	103	10-6	94	21x66	18	7-11	7-3	39	110	52	110	"	312	29300
724	35000	8625	59.4	15-9	103	10-6	94	21x71	18	7-11	7-9	40	110	54	110	"	351	32700
725	42000	10350	63.3	17-2	103	10-10	98	21x76	18	7-11	8-3	42	110	60	110	"	394	35600

Kewanee Boiler Corporation

Kewanee, Illinois

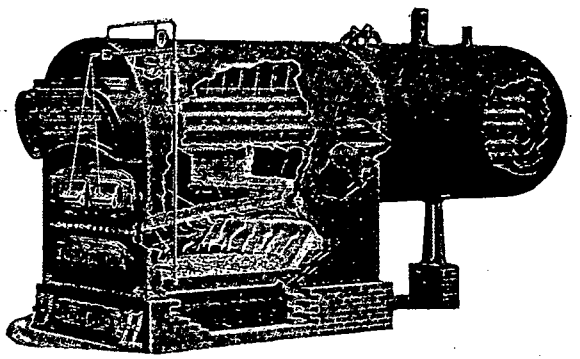
BRANCHES IN ALL PRINCIPAL CITIES

Steel Heating and Power Boilers, Water Heating Garbage Burners, Tabasco Heaters, Tanks and Radiators



KEWANEE FIREBOX BOILER—*Brick-set—for Heating*

Kewanee Firebox Boilers represent 40 years of intensive study and effort to make the highest grade equipment for heating buildings. They are adapted to the burning of any grade of fuel and will maintain high efficiency when operating to supply the variable demands of a heating load.



KEWANEE SMOKELESS BOILER—*Portable—for Heating*

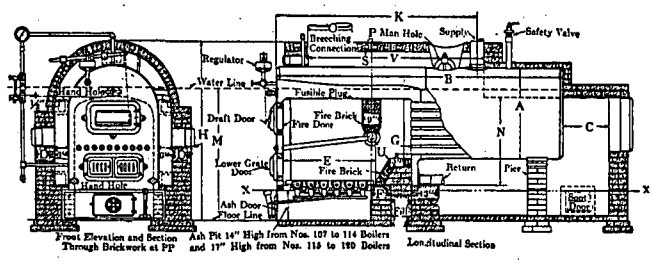
The rated capacity is the amount of direct radiation that the boiler will carry with a firing interval of three to four hours depending upon the grade of fuel used. No discount in rating is advised as reserve capacity has been allowed to care for the most severe weather conditions.

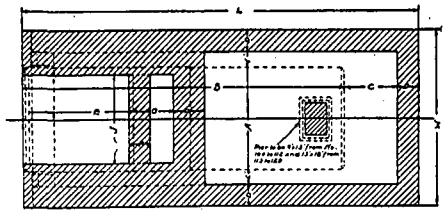
Kewanee Boilers are built of steel (riveted) using as a minimum basis the rules of construction adopted by the *American Society of Mechanical Engineers*, known as the *A. S. M. E.* Boiler Code.

Ratings

The rated capacity of Kewanee Boilers, as shown, is the number of square feet of direct radiation or equivalent which the boiler will carry, if sufficient radiation is installed to heat the building to 70 degrees Fahrenheit.

The ratings are based on a standard for steam of 2 lb. pressure at the boiler, and for water on a mean temperature of 180 deg. Fahr. as the water leaves the boiler.

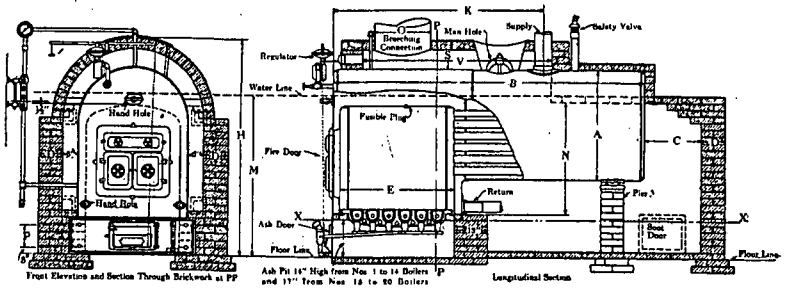


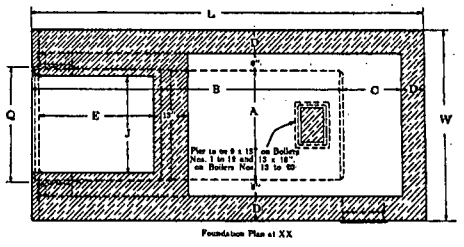


KEWANEE SMOKELESS BOILERS—BRICK-SET TYPE

Number of Boiler	104	105	106	107	108	109	110	111	112	113	114	115	116	117	118	119	120
Capacity, Steam....sq. ft.	1600	2000	2300	2600	3100	3600	4000	4700	5500	6500	7500	8500	10000	11500	13000	14000	16000
Heating Surface....sq. ft.	206	243	288	297	345	393	425	480	535	628	741	839	973	1064	1194	1291	1456
Area of Upper Grate....sq. ft.	5.9	7.2	8.4	8.6	10.1	11.4	11.8	13.2	15.0	17.1	19.1	21.1	23.3	23.5	25.9	28.5	31.3
Diameter of Boiler....in.	36	36	36	42	42	42	48	48	48	54	54	60	60	66	66	72	72
Length Boiler Over-all....ft. in.	8-7	10-2	11-7	9-10	11-4	12-10	12-4	13-10	15-4	15-9	18-3	17-10	20-4	18-4	20-4	18-4	20-4
Diameter of Stack....in.	18	18	20	20	20	22	22	24	24	28	28	32	32	34	34	36	36
Minimum Height of Stack....ft.	45	45	45	50	50	50	50	55	55	60	60	60	60	70	70	70	70
Diameter of Stack, Two Boilers....in.	24	24	26	26	28	30	30	32	32	34	36	38	38	40	42	44	46
Minimum Height of Stack, Two Boilers....ft.	55	55	55	60	60	60	60	60	60	70	70	70	75	75	80	80	80
Size of Steam Opening....in.	5	6	6	6	6	6	6	6	8	8	8	8	8	8	8	8	8
Size of Return....in.	3	3	3	4	4	4	4	4	5	5	5	5	5	6	6	6	6
Size of Safety Valve....in.	1¼	1½	2	2	2	2	2	2½	2½	3	3	3	3½	3½	4	4	2-2½
C—Rear Space....in.	17	17	17	22	22	22	22	22	22	24	24	24	24	24	24	28	28
D—Thickness Wall....in.	9	9	9	9	9	9	9	9	9	13	13	13	13	13	13	13	13
E—Length Grate....in.	31	37	43	37	43	49	43	49	55	55	61	61	67	61	67	67	73
J—Width Ash-pit....in.	31	31	31	37	37	37	43	43	43	49	49	54	54	60	60	66	66
F—Thickness Bridge Wall....in.	9	9	9	9	9	9	13	13	13	18	18	18	18	18	18	18	18
G—Grate to Tube Sheet....in.	14	14	14	17	17	17	23	23	23	23	23	29	29	29	29	29	29
U—Header to Bridge Wall....in.	7	8	9	9	10	12	10	11	12½	13	14	14	15½	14	15½	16	17
H—Height Brickwork....in.	77	77	77	83	83	83	90	90	90	96	96	108	108	114	114	120	120
K—Location Steam Supply....ft. in.	6-0	7-0	8-0	7-6	8-0	8-9	8-10	9-8	10-4	11-0	11-6	11-10	13-0	12-0	13-0	12-1	13-1
L—Length Over-all....ft. in.	10-9	12-3	13-9	12-5	13-11	15-5	14-11	16-5	17-11	18-10	21-4	20-11	23-5	21-5	23-5	21-9	23-9
M—Height Water-line....in.	55	55	55	58½	58½	58½	61	61	61	66	66	75	75	80	80	85½	85½
N—Height Side Flue....in.	36	36	36	39	39	39	42	42	42	48	48	51	51	58	58	63	63
O—Diameter Breeching Connection....in.	20	20	22	22	22	24	24	27	27	30	30	34	34	36	36	38	38
S—Top Flue Space....in.	7	7	7	7	7	7	8	8	8	8	8	10	10	10	10	10	10
V—Length of Arch....ft. in.	5-3	6-3	7-3	7-0	7-6	8-0	8-1	8-11	9-9	10-0	10-6	10-10	12-0	11-0	12-0	11-1	12-1
W—Width Over-all....ft. in.	5-6	5-6	5-6	6-0	6-0	6-0	6-6	6-6	6-6	7-8	7-8	8-2	8-2	8-8	8-8	9-2	9-2
Req'd at Rear to Draw Tubes....ft. in.	2-5	3-5	4-5	2-8	3-8	4-8	4-0	5-0	6-0	5-11	7-11	6-11	8-11	7-5	8-11	6-7	8-1
*Number Common Brick	2200	2350	2450	2600	2850	3100	3700	4000	4300	6000	6600	7350	7900	7800	8300	8700	9300
Number Fire Brick	85	85	85	100	100	100	130	130	130	155	155	215	215	250	250	310	310
*Common Brick for Two Boilers	3900	4100	4300	4500	4950	5350	6500	7000	7550	10500	11500	12750	13700	13200	14200	15000	16000

*Foundations not included.

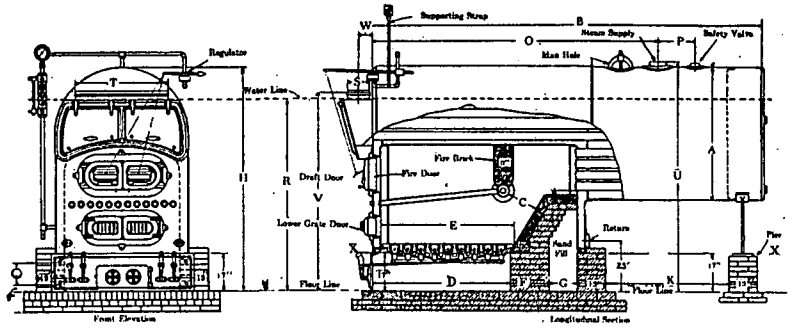


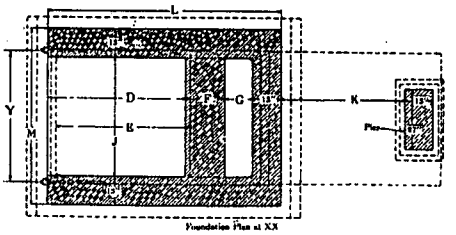


KEWANEE FIREBOX BOILERS—BRICK-SET TYPE

Number of Boiler	0	1	2	3	4	5	6	8	9	10	11	12	13	14	15	16	17	18	19	20
Capacity, Steam....sq. ft.	700	900	1050	1200	1400	1700	2000	2600	3000	3500	4000	4500	5500	6500	7500	8700	10000	11000	12000	14000
Diameter of Boiler....in.	24	30	30	30	36	36	36	42	42	48	48	48	54	54	60	60	66	66	72	72
Length of Boiler Over-all....ft.	7	6½	7½	8½	7½	9	10½	10	11½	10½	12	13½	14	16½	15½	18	16	18	16	18
Heating Surface....sq. ft.	84	113	131	147	180	215	250	305	350	368	420	472	560	673	743	873	954	1080	1167	1329
Area of Grate....sq. ft.	3.5	4.4	5.4	6.4	6.8	8.0	9.3	11.1	12.6	12.9	14.7	16.5	18.8	20.8	22.9	25.1	25.5	28.0	30.8	33.5
Diameter of Breeching....in.	10	12	14	16	16	18	18	20	22	22	24	24	28	28	32	32	32	32	36	36
Diameter of Stack....in.	10	12	12	14	14	16	16	18	20	20	22	22	26	26	30	30	30	30	34	34
Minimum Height of Stack....ft.	35	40	40	40	40	40	45	45	45	45	50	50	50	50	55	55	60	60	60	60
Diameter of Breeching, Two Boilers....in.	16	18	20	22	22	24	24	28	32	32	32	34	36	36	40	40	40	42	44	46
Diameter of Stack, Two Boilers....in.	16	18	18	20	20	22	22	26	28	28	30	32	34	34	36	36	36	38	40	42
Minimum Height of Stack, Two Boilers....ft.	40	45	45	45	45	45	45	50	50	50	50	50	55	60	60	70	70	70	70	70
Size of Steam Opening....in.	3	4	4	5	5	6	6	6	6	6	6	8	8	8	8	8	8	8	8	8
Size of Return....in.	2	2½	2½	3	3	3	3	4	4	4	4	5	5	5	5	5	6	6	6	6
Size of Safety Valve....in.	1	1¼	1¼	1¼	1½	1½	2	2	2	2	2½	2½	2½	3	3	3½	3½	3½	4	4
C—Rear Space....in.	14	17	17	17	17	17	17	22	22	22	22	22	24	24	24	24	24	24	28	28
D—Thickness Wall....in.	9	9	9	9	9	9	9	9	9	9	9	9	13	13	13	13	13	13	13	13
E—Length Grate....in.	26	26	32	38	32	38	44	44	50	44	50	56	56	62	62	68	62	68	68	74
J—Width Ash-pit....in.	19	25	25	25	31	31	31	37	37	43	43	43	49	49	54	54	60	60	66	66
H—Total Height....in.	64	70	70	70	77	77	77	83	83	90	90	90	96	96	108	108	114	114	120	120
K—Location of Supply....ft. in.	4-0	4-0	4-8	5-6	4-11	5-11	6-11	6-8	7-2	7-0	7-10	8-6	9-2	9-8	9-6	10-8	9-8	10-8	9-9	10-9
M—Height of Water-line....in.	47	52	52	52	55	55	55	58½	58½	61	61	61	66	66	75	75	80	80	85½	85½
N—Height of Side Flue....ft. in.	2-6	2-8	2-8	2-8	3-0	3-0	3-0	3-3	3-3	3-6	3-6	3-6	4-0	4-0	4-3	4-3	4-10	4-10	5-3	5-3
O—Diameter Breeching Connection....in.	10	12	14	16	16	18	18	20	22	22	24	24	28	28	32	32	32	32	36	36
S—Top Flue Space....in.	6	6	6	6	7	7	7	7	7	8	8	8	8	8	10	10	10	10	10	10
V—Length of Arch....ft. in.	3-2	3-2	3-10	4-9	4-1	5-1	6-1	6-3	6-9	6-3	7-3	7-9	8-1	8-7	8-5	9-7	8-7	9-8	8-9	9-9
P—Anchor Bolt Centers for Ash-pit Front..in.	8	8	8	8	8	8	8	8	8	8	8	8	8	8	11	11	11	11	11	11
Q—Anchor Bolt Centers for Ash-pit Front..in.	24	30	30	30	36	36	36	42	42	48	48	48	54	54	60	60	66	66	72	72
L—Total Length....ft. in.	8-8	8-7	9-8	10-8	9-8	11-2	12-8	12-7	14-1	13-1	14-7	16-1	17-0	19-6	18-7	21-1	19-1	21-1	19-5	21-5
W—Total Width....ft. in.	4-6	5-0	5-0	5-0	5-6	5-6	5-6	6-0	6-0	6-6	6-6	6-6	7-8	7-8	8-2	8-2	8-8	8-8	9-2	9-2
*Number of Common Brick	1325	1450	1600	1750	1900	2150	2400	2650	2900	3000	3300	3600	5300	5900	6500	7200	7200	7700	7700	8200
*Common Brick for Two Boilers	2250	2450	2700	2950	3300	3750	4100	4750	5350	5400	5900	6450	8350	10350	11350	12550	12400	13450	13250	13850

*Foundations not included. NOTE—A Firing Space of about 8'-0" should be maintained at front of Boilers. This provides sufficient space to draw tubes through firedoor.

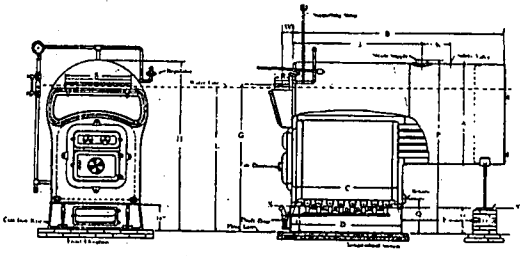


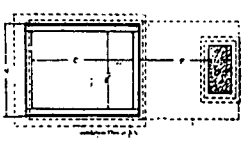


KEWANEE SMOKELESS BOILERS—PORTABLE TYPE

Number of Boiler	307	308	309	310	311	312	313	314	315	316	317	318	319	320	321	322	323	324
Capacity, Steam....sq. ft.	3000	3500	4000	4500	5000	5500	6000	6500	7500	8500	10000	12000	14000	16000	18000	20000	25000	30000
Heating Surface....sq. ft.	297	352	391	446	496	546	592	643	721	773	912	1053	1204	1316	1458	1549	2074	2629
Area of Upper Grate....sq. ft.	8.8	10.1	11.4	12.9	14.7	16.5	17.1	18.5	20.0	21.4	23.5	25.9	28.5	29.9	32.6	34.6	41.7	44.8
Diameter of Boiler....in.	48	48	48	54	54	54	60	60	60	60	66	66	72	72	78	78	84	84
Length of Boiler Over-all....ft. in.	9-1	10-5	11-5	10-11	11-11	12-11	12-11	13-11	15-3	16-3	15-9	17-9	16-7	17-11	17-10	18-10	20-1	24-1
Diameter of Stack....in.	20	20	20	22	22	22	24	24	26	26	28	30	32	32	34	34	38	40
Minimum Height of Stack....ft.	50	55	55	55	55	60	60	60	65	65	65	70	70	70	80	90	90	100
Diameter of Stack, Two Boilers....in.	28	28	28	31	31	31	34	34	36	36	40	42	46	46	48	48	54	54
Minimum Height of Stack, Two Boilers....ft.	60	65	65	65	65	70	70	70	75	75	75	80	80	80	90	100	100	110
Size of Steam Opening....in.	6	6	6	6	6	6	8	8	8	8	8	8	8	8	8	8	10	10
Size of Return....in.	4	4	4	4	4	4	5	5	5	6	6	6	6	6	6	6	6	6
Size of Safety Valve....in.	2	2	2	2½	2½	2½	3	3	3	3½	3½	4	4	4	2-2½	2-3	2-3	2-3½
Distance Required to Open Rear Flue Doors....in.	26	26	26	28	28	28	32	32	32	32	35	35	37	37	40	40	43	43
E—Length Grate....in.	37	43	49	49	55	61	55	61	61	67	61	67	67	73	73	73	79	85
C—Header to Bridge Wall....in.	9	10	11½	11	12½	14	12½	14	14	15	15	16	16	17	17	18	18	19
D—Length Ash-pit....in.	38	44	50	50	56	62	56	62	63	69	63	69	69	75	75	75	81	87
K—Rear Wall to Pier....in.	29	39	45	27	33	39	45	51	57	63	62	80	63	74	72	79	84	126
J—Width Ash-pit....in.	37	37	37	43	43	43	49	49	53	53	59	59	65	65	71	71	77	77
M—Width Foundation....in.	46	46	46	60	60	60	66	66	79	79	85	85	91	91	97	97	103	103
L—Length Foundation....in.	61	67	73	84	90	96	90	96	107	113	107	113	113	119	119	125	131	137
H—Height Boiler....in.	84	84	84	89	89	89	98	98	101	101	107	107	113	113	115	115	121	121
U—Height Supply....in.	85	85	85	90	90	90	99	99	103	103	109	109	115	115	117	117	123	123
R—Height Water-line....in.	71	71	71	76	76	76	83	83	87	87	90	90	96	96	97	97	105	105
V—Height of Breeching Connection....in.	76	76	76	80	80	80	88	88	90	90	93	93	100	100	101	101	109	109
O—Location Supply....ft. in.	5-11	6-8	7-3	7-6	8-2	8-9	8-9	9-3	10-11	11-6	11-0	11-9	11-7	12-2	12-2	12-9	13-8	15-0
P—Location Safety Valve....in.	12	14	14	13	13	15	15	18	16	18	16	18	15	18	18	16	18	20
W—Center Breeching Connection to Front of Boiler....in.	8	8	8	8	8	8	9¼	9¼	9¼	9¼	10½	10½	11½	11½	11½	11½	13	13
S—Width Breeching Connection....in.	10	10	10	10	10	10	12½	12½	12½	12½	15	15	17	17	17	17	20	20
T—Length Breeching Connection....in.	36	36	36	42	42	42	46	46	46	46	50	50	54	54	60	60	64	64
†Req'd at Front to Draw Tubes....ft. in.	7-7	8-11	9-11	9-5	10-5	11-5	11-5	12-5	13-8	14-8	14-0	16-0	14-8	16-0	16-0	17-0	18-0	22-0
†Req'd at Rear to Draw Tubes....ft. in.	6-0	7-4	8-4	7-10	8-10	9-10	9-10	10-10	12-2	13-2	12-4	14-4	12-10	14-2	14-1	15-1	16-0	20-0
*Number Common Brick....	200	200	200	800	825	850	1025	1050	1300	1350	1300	1350	1375	1450	1400	1475	1575	1600
Number Fire-brick....	115	115	115	155	155	155	195	195	210	215	240	240	255	255	290	315	425	425
Outside Surface to be Covered....sq. ft.	148	157	173	184	212	221	255	265	266	280	290	330	335	360	370	400	455	545

*Foundations not included. †If space is available at front, it is not necessary at rear, and vice-versa.

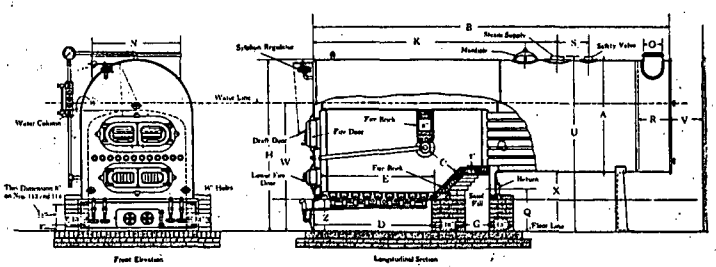


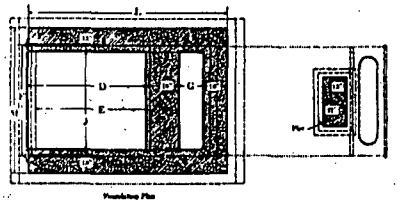


KEWANEE BOILERS—PORTABLE TYPE

Number of Boiler	407	408	409	410	411	412	413	414	415	416	417	418	419	420	421	422	423	424
Capacity, Steam....sq. ft.	2500	2900	3500	4000	4500	5000	5500	6000	7000	8000	9500	11000	13000	15000	17500	20000	25000	28000
Heating Surface....sq. ft.	278	310	373	416	465	515	565	626	676	778	929	1040	1168	1303	1514	1711	2209	2427
Area of Grate....sq. ft.	9.6	11.1	12.6	12.9	14.7	16.5	18.8	20.8	20.7	22.9	25.5	28.0	30.8	33.5	36.6	39.6	42.9	46.1
Diameter of Boiler....in.	48	48	48	54	54	54	60	60	60	60	66	66	72	72	78	78	84	84
Length of Boiler....ft. in.	8-7	9-6	11-1	10-0	11-1	12-1	12-5	13-7	14-4	16-2	15-9	17-4	15-11	17-6	17-11	19-11	20-1	22-1
Diameter of Stack....in.	20	20	20	22	22	22	24	24	26	26	28	30	32	32	34	34	38	40
Minimum Height of Stack....ft.	50	50	55	55	55	60	60	60	65	65	65	70	70	70	80	90	90	100
Diameter of Stack, Two Boilers....in.	28	28	28	31	31	31	34	34	36	36	40	42	46	46	48	48	54	54
Minimum Height of Stack, Two Boilers....ft.	60	60	65	65	65	70	70	70	75	75	75	80	80	80	90	100	100	110
Size of Steam Opening....in.	6	6	6	6	6	6	8	8	8	8	8	8	8	8	8	8	10	10
Size of Return....in.	4	4	4	4	4	4	5	5	5	5	6	6	6	6	6	6	6	6
Size of Safety Valve....in.	2	2	2	2	2½	2½	2½	3	3	3	3½	3½	4	4	2-2½	2-3	2-3	2-3
Distance Required to Open Rear Flue Doors....in.	26	26	26	28	28	28	32	32	32	32	35	35	37	37	40	40	43	43
C—Length of Fire-box....in.	38	44	50	44	50	56	56	62	56	62	62	68	68	74	74	80	80	86
D—Length of Ash-pit....in.	45	51	57	47	53	59	59	65	60	66	66	72	72	78	78	84	84	90
E—Width of Fire-box....in.	36	36	36	43	43	43	49	49	53	53	59	59	65	65	71	71	77	77
F—Ash-pit Base to Pier....ft. in.	3-3	3-8	4-9	3-9	4-4	4-10	5-2	5-10	6-7	7-11	7-5	8-5	6-11	7-11	8-4	9-10	9-10	11-4
G—Height Breeching Connection....in.	76	76	76	80	80	80	88	88	90	90	93	93	100	100	101	101	109	109
H—Height of Boiler....in.	84	84	84	89	89	89	98	98	101	101	107	107	113	113	115	115	121	121
P—Height of Steam Supply....in.	85	85	85	90	90	90	99	99	103	103	109	109	115	115	117	117	123	123
L—Height of Water-line....in.	71	71	71	76	76	76	83	83	87	87	90	90	96	96	97	97	105	105
J—Location of Steam Supply....ft. in.	4-8	5-3	6-3	5-6	6-4	8-0	8-3	8-8	8-5	9-5	9-4	10-2	9-8	11-1	11-3	12-0	12-6	12-6
K—Location of Safety Valve....in.	13	14	18	16	18	13	16	18	21	29	18	32	18	26	24	30	24	21
W—Center of Breeching Connection to Front of Boiler....in.	8	8	8	8	8	8	9¼	9¼	9¼	9¼	10½	10½	11½	11½	11½	11½	13	13
R—Width Breeching Connection....in.	10	10	10	10	10	10	12½	12½	12½	12½	15	15	17	17	17	17	20	20
S—Length Breeching Connection....in.	36	36	36	42	42	42	46	46	46	46	50	50	54	54	60	60	64	64
†Req'd at Front to Draw Tubes....ft. in.	7-1	8-0	9-7	8-7	9-7	10-7	11-0	12-2	12-10	14-8	14-1	15-8	14-1	15-8	16-1	18-1	18-1	20-1
†Req'd at Rear to Draw Tubes....ft. in.	5-6	6-5	8-0	6-11	7-11	8-11	9-4	10-6	11-3	13-1	12-4	13-11	12-2	13-9	14-2	16-2	16-2	18-2
*Number Common Brick....	70	70	70	450	480	510	530	560	680	710	740	760	790	820	840	885	900	935
Outside Surface to be Covered....sq. ft.	115	130	150	155	175	185	190	220	250	280	290	310	315	345	385	425	455	505

*Foundations not included. †If space is available at front, it is not necessary at rear, and vice-versa.

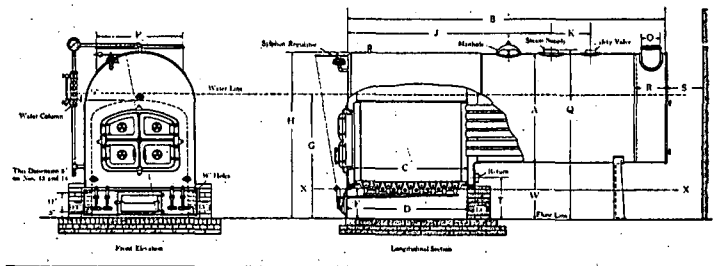


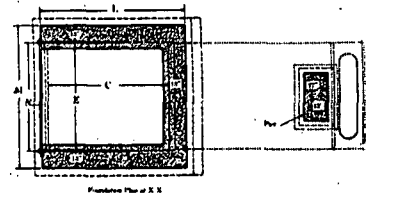


KEWANEE PORTABLE SMOKELESS BOILERS TYPE K

Number of Boiler	104K	105K	106K	107K	108K	109K	110K	111K	112K	113K	114K	115K	116K	117K	118K	119K	120K
Capacity, Steam...sq. ft.	1500	1900	2200	2500	2900	3400	3800	4400	5200	6200	7100	8100	9500	10900	12300	13300	15200
Heating Surface...sq. ft.	157	185	220	234	271	308	338	381	425	500	590	677	787	879	987	1090	1230
Area of Upper Grate...sq. ft.	5.9	7.2	8.4	8.6	10.1	11.4	11.8	13.2	15.0	17.1	19.1	21.1	23.3	23.5	25.9	28.5	31.3
Diameter of Boiler...in.	36	36	36	42	42	42	48	48	48	54	54	60	60	66	66	72	72
Length Boiler Over-all...ft. in.	9-11	11-5	12-11	11-2	12-8	14-2	13-8	15-2	16-8	17-1	19-7	19-4	21-10	19-10	21-10	19-10	21-10
Diameter of Stack...in.	18	18	20	20	20	22	22	24	24	28	28	32	32	34	34	36	36
Minimum Height of Stack...ft.	40	40	40	45	45	45	45	50	50	55	55	55	55	65	65	65	65
Diameter of Stack, Two Boilers...in.	24	24	26	26	28	30	30	32	32	34	36	38	38	40	42	44	46
Minimum Height of Stack, Two Boilers...ft.	50	50	50	55	55	55	55	55	55	65	65	65	70	70	75	75	75
Size of Steam Opening...in.	5	6	6	6	6	6	6	6	8	8	8	8	8	8	8	8	8
Size of Return...in.	3	3	3	4	4	4	4	4	5	5	5	5	5	6	6	6	6
Size of Safety Valve...in.	1½	1½	2	2	2	2	2	2½	2½	3	3	3	3½	3½	4	4	2-2½
C—Header to Bridge Wall...in.	7	8	9	9	10	12	10	11	12½	13	14	14	15½	14	15½	16	17
D—Length of Ash-pit...in.	32	38	44	38	44	50	44	50	56	57	63	63	69	63	69	69	75
E—Length of Grate...in.	31	37	43	37	43	49	43	49	55	55	61	61	67	61	67	67	73
F—Center to Center Bolts in Ash-pit Front...in.										54	54	60	60	66	66	72	72
G—Bridge Wall to Rear Wall...in.										6	6	12	12	12	12	12	12
H—Height of Boiler...in.	65	65	65	71	71	71	77	77	77	83	83	93	93	99	99	105	105
J—Width of Ash-pit...in.	31	31	31	37	37	37	43	43	43	49	49	54	54	60	60	66	66
K—Location of Steam Supply...ft. in.	6-0	7-0	8-0	7-6	8-0	8-9	8-10	9-8	10-4	11-0	11-6	11-10	13-0	12-0	13-0	12-1	13-1
L—Length of Foundation...in.	51	57	63	60	66	72	72	78	84	94	100	106	112	106	112	112	118
M—Width of Foundation...in.	40	40	40	46	46	46	54	54	54	75	75	80	80	86	86	92	92
N—Length of Breeching Connection...in.	24	24	24	30	30	30	36	36	36	46	46	50	50	54	54	68	68
O—Width of Breeching Connection...in.	10	10	10	10	10	10	10	10	10	10	10	12	12	12	12	13	13
Q—Height of Return...in.	19	19	19	19	19	19	19	19	20	20	20	23	23	23	23	23	23
R—Depth of Smoke Box...in.	16	16	16	16	16	16	16	16	16	16	16	18	18	18	18	18	18
S—Location of Safety Valve...in.	15	18	18	13	12	13	16	18	18	21	30	26	30	30	30	20	34
U—Height of Steam Supply...in.	67	67	67	73	73	73	79	79	79	85	85	95	95	101	101	107	107
V—Minimum Space Required at Rear...in.	21	21	21	24	24	24	27	27	27	30	30	33	33	36	36	39	39
W—Height of Water-line...in.	55	55	55	58½	58½	58½	61	61	61	66	66	75	75	80	80	85½	85½
X—Floor Line to Bottom of Cylinder...in.	29	29	29	29	29	29	29	29	29	29	29	33	33	33	33	33	33
Z—Height of Ash-pit...in.	14	14	14	14	14	14	14	14	14	14	14	17	17	17	17	17	17
†Req'd at Front to Draw Tubes...in.	7	13	19	4	10	16	10	16	22	27	45	26	44	32	44	20	32
†Req'd at Rear to Draw Tubes...in.	39	51	63	45	57	69	63	75	87	92	116	102	126	108	126	102	120
*Number of Common Brick										955	980	1300	1350	1300	1350	1375	1450
Number of Fire Brick	85	85	85	115	115	115	155	155	155	195	195	210	215	240	240	255	255
Outside Surface to be Covered...sq. ft.	93	102	115	131	148	164	180	199	218	243	278	311	350	350	384	380	407

*Foundations not included. †If space is available at front, it is not necessary at rear, and vice-versa. Boilers No. 104K to 112K are furnished with cast iron bases





KEWANEE BOILERS PORTABLE TYPE K—UP-DRAFT

Number of Boiler	0K	1K	2K	3K	4K	5K	6K	8K	9K	10K	11K	12K	13K	14K	15K	16K	17K	18K	19K	20K
Capacity, Steam...sq. ft.	600	850	1000	1150	1300	1600	1900	2450	2850	3300	3800	4300	5200	6200	7100	8200	9500	10400	11400	13300
Heating Surface...sq. ft.	61	83	93	104	139	164	190	241	275	298	338	378	447	537	603	708	791	896	992	1129
Area of Grate...sq. ft.	3.5	4.4	5.4	6.4	6.8	8.0	9.3	11.1	12.6	12.9	14.7	16.5	18.8	20.8	22.9	25.1	25.5	28.0	30.8	33.5
Diameter of Boiler...in.	24	30	30	30	36	36	36	42	42	48	48	48	54	54	60	60	66	66	72	72
Length of Boiler Over-all...ft. in.	7-9	7-10	8-10	9-10	8-10	10-4	11-10	11-4	12-10	11-10	13-4	14-10	15-4	17-10	17-0	19-6	17-6	19-6	17-6	19-6
Diameter of Stack...in.	10	12	12	14	14	16	16	18	20	20	22	22	26	26	30	30	30	30	34	34
Minimum Height of Stack...ft.	35	35	35	35	35	40	40	40	40	40	45	45	45	45	50	50	55	55	55	55
Diameter of Stack, Two Boilers...in.	16	18	18	20	20	22	22	26	28	28	30	32	34	34	36	36	36	38	40	42
Minimum Height of Stack, Two Boilers...ft.	40	40	40	40	40	40	40	45	45	45	45	45	50	55	55	65	65	65	65	65
Size of Steam Opening...in.	3	4	4	5	5	6	6	6	6	6	6	8	8	8	8	8	8	8	8	8
Size of Return...in.	2	2½	2½	3	3	3	3	4	4	4	4	5	5	5	5	5	6	6	6	6
Size of Safety Valve...in.	1	1¼	1¼	1¼	1½	1½	2	2	2	2	2½	2½	2½	3	3	3½	3½	3½	4	4
C—Length of Grate...in.	26	26	32	38	32	38	44	44	50	44	50	56	56	62	62	68	62	68	68	74
D—Length of Ash-pit...in.	31	33	39	45	39	45	51	51	57	51	57	63	59	65	65	71	65	71	71	77
E—Width of Ash-pit...in.	19	24	24	24	30	30	30	36	36	42	42	42	49	49	54	54	60	60	66	66
F—Height of Ash-pit...in.	12	14	14	14	14	14	14	14	14	14	14	14	14	14	17	17	17	17	17	17
G—Height of Water-line...in.	45	52	52	52	55	55	55	58½	58½	61	61	61	66	66	75	75	80	80	85½	85½
H—Height of Boiler...in.	51	59	59	59	65	65	65	71	71	77	77	77	83	83	93	93	99	99	105	105
J—Location of Steam Supply...ft. in.	4-0	4-0	4-8	5-6	4-11	5-11	6-11	6-8	7-2	7-0	7-10	8-6	9-2	9-8	9-6	10-8	9-8	10-8	9-9	10-9
K—Location of Safety Valve...in.	12	12	15	16	15	18	18	13	13	16	18	18	21	30	26	30	26¼	30	20	34
L—Length of Foundation...in.	32	34	40	46	40	46	52	52	58	52	58	64	72	78	78	84	78	84	84	90
M—Width of Foundation...in.	27	34	34	34	40	40	40	46	46	52	52	52	75	75	80	80	86	86	92	92
N—Center to Center Bolts in Ash-pit Front...in.													54	54	60	60	66	66	72	72
O—Width of Breeching Connection...in.	10	8	8	8	10	10	10	10	10	10	10	10	10	10	12	12	12	12	13	13
P—Length of Breeching Connection...in.	10	16	16	16	24	24	24	30	30	36	36	36	46	46	50	50	54	54	68	68
Q—Height of Steam Supply...in.	53	61	61	61	67	67	67	73	73	79	79	79	85	85	95	95	101	101	107	107
R—Depth of Smoke Box...in.	12	16	16	16	16	16	16	16	16	16	16	16	16	16	18	18	18	18	18	18
S—Minimum Space Required at Rear...in.	24	18	18	18	21	21	21	24	24	27	27	27	30	30	33	33	36	36	39	39
T—Height of Return...in.	15½	18	18	19	19	19	19	19	19	19	19	20	20	20	23	23	23	23	23	23
W—Floor Line to Bottom of Cylinder...in.	27	29	29	29	29	29	29	29	29	29	29	29	29	29	33	33	33	33	33	33
†Req'd at Front to Draw Tubes...in.		19	20	20	20	26	31	26	32	32	38	44	49	67	55	73	61	73	49	62
†Req'd at Rear to Draw Tubes...in.		32	39	45	39	51	63	57	69	63	75	87	92	116	102	126	108	126	102	122
*Number of Common Brick													460	490	710	740	740	760	790	820
Outside Surface to be Covered...sq. ft.	55	68	77	85	91	106	120	133	149	157	177	197	200	235	275	314	311	345	338	366

*Foundations not included. †If space is available at front, it is not necessary at rear, and vice-versa. Boilers No. 0K to No. 12K are furnished with cast iron base.
Full height back stand furnished with all boilers, no pier, see Letter W.

Leader Iron Works

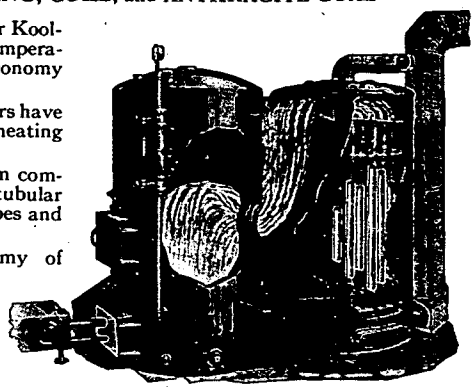
General Offices: 3010 N. Jasper St., **Decatur, Illinois**

New York	Chicago	St. Louis
21 E. 40th Street	451 W. Erie Street	2091 Ry. Exchange Building

KOOLSTACK BOILERS

for

OIL BURNING, COKE, and ANTHRACITE COAL



Low Stack Temperature. Leader Koolstack Boilers operate with stack temperatures of less than 300 deg. fahr. Economy is the result.

Heating Surface. Koolstack Boilers have far more than the usual amount of heating surface.

Fire Travel. Flue gases pass from combustion chamber to the top of rear tubular section, then down through the tubes and out at the bottom.

Economy. The unusual economy of Leader Koolstack Boilers is due to the fact the flue gases are held in the boiler until all of the effective heat has been released.

Automatic Damper. Temporary draft acceleration at the initial firing period is provided by an automatic damper which by-passes the products of combustion direct to the chimney. This damper closes automatically when the stack temperature reaches 250 deg.

For Oil, Coke, and Anthracite Coal. While this is primarily a boiler for Oil Burning, it shows remarkable performance records on Coke and Anthracite Coal. It is not intended for use with soft coal.

Koolstack Boiler Specifications

(*A.S.M.E.* Code)

STEAM HEATING

Type	Net Rating Sq. Ft. Note ‡	Approximate Shipping Weight Lb.	Grate Diameter In.	Width Overall In.	Height Overall In.	Length Overall In.	Size Smoke Outlet In.	Size Flow Opening In.	Size Return Opening In.	Height of Water Level In.
OS-2848	800	2000	23½	36½	52¾	68½	10	3	3	37½
OS-2854	1000	2200	23½	36½	59½	68½	10	3½	3½	42½
OS-2860	1200	2400	23½	36½	65½	68½	10	4	4	46½
OS-3954	1600	3500	33½	46	61	90	12	4½	4½	42½
OS-3963	2100	3900	33½	46	70¾	90	12	4½	4½	48½
OS-3972	2600	4300	33½	46	79¾	90	12	5	5	56

HOT WATER HEATING

OW-2848	1280	2000	23½	36½	52¾	68½	10	3	3	.....
OW-2854	1600	2200	23½	36½	59½	68½	10	3½	3½	.....
OW-2860	1920	2400	23½	36½	65½	68½	10	4	4	.....
OW-3954	2880	3500	33½	46	61	90	12	4½	4½	.....
OW-3963	3520	3900	33½	46	70¾	90	12	4½	4½	.....
OW-3972	4160	4300	33½	46	79¾	90	12	5	5	.....

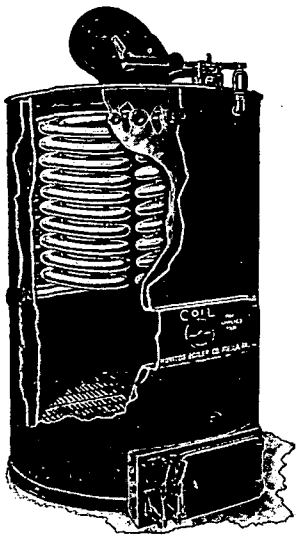
‡All of these ratings are based on actual boiler capacity at outlet.

Monitor Boiler Company

1505 Race Street **Philadelphia, Pa.**

COIL STEEL HEATING BOILERS AND WATER HEATERS

OIL OR COAL BURNING



It is the amount of heating surface, provided it is properly placed in relation to the fire, that determines the amount of oil or coal used to heat a building. The amount of heating surface per unit of rating in the Coil Boiler is exceptionally high and is tremendously effective because it is within view of the flame, hence, capable of absorbing the radiant heat.

NET RATINGS

The Coil Water Tube Steel Boiler is rated on the amount of direct cast-iron radiation the boiler will carry. EXAMPLE: A boiler rated at 800 ft. will carry 800 ft. of direct cast-iron radiation. A sufficient reserve has been figured in the rating to take care of piping, except where unusual conditions exist, such as exposed piping, insufficient radiation, etc., where allowance must of course be made.

DIMENSIONS AND RATINGS

COIL WATER TUBE STEEL HEATING BOILERS						COIL STEEL WATER HEATERS			
Number of Boiler	Net Steam Rating	Net Water Rating	Grate Area Sq. Ft.	Tappings No. and Size	Smoke Pipe	Number of Heater	Capacity Gal. per Hour	Smoke Pipe	Tappings No. and Size
S&W 1181	325	525	1.8	4–2½	7″	10	400	7″	4–2½
S&W 1201	450	750	2.2	4–2½	7″	12	500	7″	4–2½
S&W 1231	550	900	2.9	4–3	8″	14	750	8″	4–3
S&W 1251	675	1100	3.4	4–3	8″	16	950	8″	4–3
S&W 1281	800	1325	4.3	4–3	10″	18	1150	10″	4–3
S&W 1282	950	1575	4.3	4–3	10″	20	1450	10″	4–4
S&W 1311	1150	1900	5.3	4–4	10″	44	1650	10″	4–4
S&W 1312	1400	2325	5.3	4–4	10″	48	2050	12″	4–4
S&W 1351	1600	2600	6.7	4–4	12″				
S&W 1352	1950	3250	6.7	4–4	12″				
S&W 1401	2350	3800	8.8	4–4	14″				
S&W 1402	3000	5000	8.8	4–4	14″				

Above ratings based on raising temperature of water 50 deg. per gallon per hour.
Working pressure 125 lb.

All Boilers and Heaters built in accordance with the *A.S.M.E.* Code.

Molby Boiler Company *Incorporated*

Subsidiary of The Universal Pipe and Radiator Company

Molby Magazine-Feed Downdraft-Crossdraft Boilers and Heavy Duty Tank Heaters *with Adjustable Side Grate for burning No. 1 Buckwheat Anthracite*

GRAYBAR BUILDING, LEXINGTON AVENUE AT 43rd STREET, NEW YORK

PHILADELPHIA BRANCH
2401 Chestnut Street

LANSDALE, PA. BRANCH
50 Central Avenue

CHICAGO BRANCH
332 S. Michigan Avenue

Highest Medal Award of Merit and Diploma: Sesqui-Centennial, Philadelphia



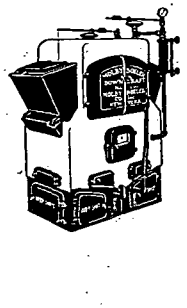
Built throughout in accordance with codes of the *A.S.M.E.* and the *A.S.H.&V.E.*

THE MOLBY is easy to operate, is self feeding, and gives a steady, even heat over long periods with low-priced No. 1 Buckwheat Anthracite. Also burns sized free-burning bituminous with proper chimney draft. Also coke. Magazines need re-filling only once every 12 to 24 hours. Cast iron sectional construction throughout.

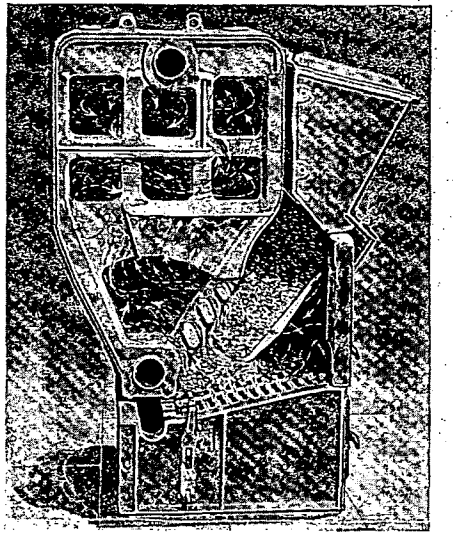
Ratings are based on the assumption that a good grade of No. 1 Buckwheat Anthracite is to be used and that the chimney is of such area, height and tightness as to produce the required draft; also that the boiler, mains and connections shall be covered with an insulating material. These ratings, under the same conditions, may be used for sized soft coal of the free-burning and non-caking variety.

Should larger sizes of good grades of Anthracite be used, a given boiler—other conditions being the same—would burn with equal efficiency, 20 per cent more coal. Thus, when such larger sizes are regularly used, the ratings shown are increased 20 per cent.

The MOLBY will heat home—large apartment house—or commercial building—having a good chimney, just as successfully and just as easily with low-priced small coal as ordinary boilers burning the expensive sizes.



THE cross-sectional views on this and the next page show the construction of the sections and the relative position of the reserve coal in the magazine. Note the downdraft and crossdraft travel of the gases through the fire and into the combustion chamber.



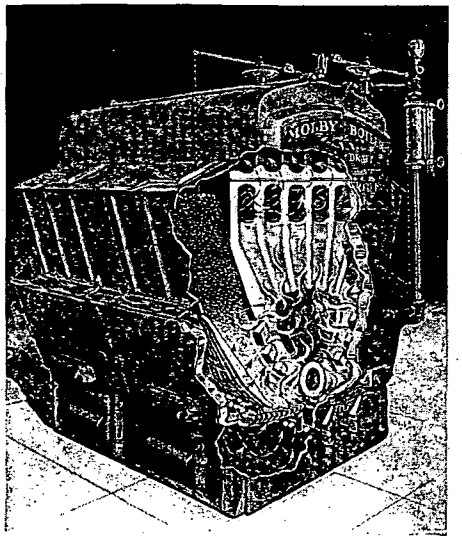
SIZES, CAPACITIES, DIMENSIONS AND PRICES

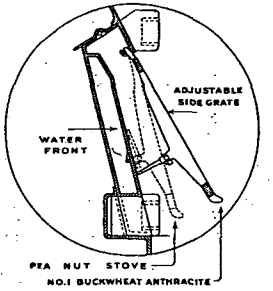
STEAM					STEAM AND WATER							WATER			
					Size—Inches										
Number	Steam Vapor	Water Line	Returns	Steam Rating No. 1 Buckwheat	Height	Width	Length	Smoke Pipe	Outlets	Chimney Flue	Approximate Shipping Weight	Number	Water Cipher	Return	Water Rating No. 1 Buckwheat
26" Series															
S-4026	Adageo	48	2-3	550	54	41	35½	10	2-3	8 x 12	1890	W-4026	Domo	2-3	925
S-5026	Addieo	48	2-3	725	54	41	42	10	2-3	8 x 12	2230	W-5026	Doseo	2-3	1225
S-6026	Admito	48	2-3	900	54	41	48½	10	2-3	8 x 12	2580	W-6026	Doffo	2-3	1525
S-7026	Adzo	48	2-3	1125	54	41	55	10	2-3	12 x 12	2950	W-7026	Doveo	2-3	1900
S-8026	Adelo	48	2-3	1300	54	41	61½	10	2-3	12 x 12	3300	W-8026	Docko	2-3	2200
31" Series															
S- 4031	Bugo	54	2-4	1075	62½	61	37⅝	14	2-3	8 x 12	3320	W- 4031	Edamo	2-4	1825
S- 5031	Buffo	54	2-4	1425	62½	61	44	14	2-3	12 x 12	3820	W- 5031	Edgeo	2-4	2425
S- 6031	Bullo	54	2-4	1775	62½	61	50⅜	14	2-3	12 x 12	4290	W- 6031	Edito	2-4	3000
S- 7031	Buno	54	2-4	2125	62½	61	56¾	14	3-3	12 x 16	4690	W- 7031	Edicto	2-4	3625
S- 8031	Bulbo	54	2-4	2475	62½	61	63⅛	14	3-3	12 x 16	5100	W- 8031	Edeno	2-4	4200
S- 9031	Buoyo	54	2-4	2825	62½	61	69½	14	3-3	16 x 16	5510	W- 9031	Educeo	2-4	4825
S-10031	Bungo	54	2-4	3175	62½	61	75⅞	14	3-3	16 x 16	5930	W-10031	Eduxo	2-4	5400
47" Series															
S- 5047	Calxo	67½	2-5	2750	80	75½	50½	14	2-4	12 x 16	5990	W- 5047	Fluxo	2-5	4675
S- 6047	Calfo	67½	2-5	3400	80	75½	59	14	2-4	16 x 16	7150	W- 6047	Fledo	2-5	5800
S- 7047	Caro	67½	3-5	4050	80	75½	67½	16	3-4	16 x 16	8310	W- 7047	Flipo	3-5	6900
S- 8047	Carpo	67½	3-5	4700	80	75½	76	16	3-4	16 x 20	9500	W- 8047	Flowo	3-5	8050
S- 9047	Caseo	67½	3-5	5350	80	75½	84½	18	3-4	16 x 20	10650	W- 9047	Flungo	3-5	9150
S-10047	Cadio	67½	3-5	6000	80	75½	93	18	4-4	20 x 20	11840	W-10047	Flusho	3-5	10300
S-11047	Cabo	67½	3-5	6650	80	75½	101½	18	4-4	20 x 20	13000	W-11047	Flinto	3-5	11400
S-12047	Cando	67½	3-5	7300	80	75½	110	18	4-4	20 x 24	14150	W-12047	Flato	3-5	12500
S-13047	Camo	67½	3-5	7950	80	75½	118½	18	4-4	20 x 24	15320	W-13047	Fleigo	3-5	13600

Note.—In ordering 26 in. boilers state whether you wish same fitted up with right hand or left hand end to the chimney. Length includes Smoke Box.

Equipment.—Each steam boiler is equipped with a full set steam trimmings (26 in. series, 1 pressure regulator; 31 in. and 47 in. series, 2 pressure regulators.)

Water boilers are furnished with two water temperature regulators, except 26 in. series which are equipped with one. A complete set of firing and cleaning tools, together with instruction books for setting up and operation, accompany each boiler.





Side grate easily adjusted for small coal or large coal

LOSS of valuable heat units is impossible because the fuel is added to the *draft side* of the fire.

The air supporting the combustion enters the fire chamber through the *adjustable side grate*, passes through the incandescent fire and is drawn through the water grate with the gases at a flaming temperature. Air and gases mix upon entering the combustion chamber.

NATIONAL RADIATOR CORPORATION

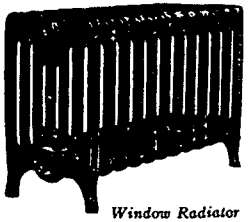
General Offices: **Johnstown, Pa.**

Branch Offices and Warehouses

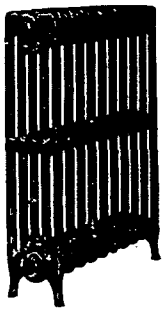
BALTIMORE	2622 Frisby Street	MILWAUKEE	124-130 Jefferson Street
BOSTON	93-97 Oliver Street	NEW YORK	55 West Forty-second Street
BUFFALO	259-265 Delaware Avenue	OMAHA	108-112 S. Tenth Street
CHICAGO	2445 North Keeler Avenue	PHILADELPHIA	121 North Broad Street
CINCINNATI	Spring Grove and Elmira Avenue	PITTSBURGH	1509 Arrott Building
CLEVELAND	935 East Sixty-third Street	RICHMOND	3032 Norfolk Street
INDIANAPOLIS	431 W. Georgia Street	ST. LOUIS	1042 Central Industrial Street
JOHNSTOWN	221 Central Avenue	WASHINGTON, D. C.	2205 Fifth Street, N.E.

Manufacturers of

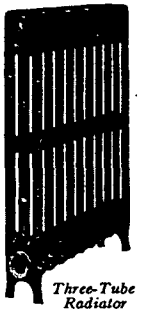
Aero Radiators, National Round Boilers, National Jacketed Boilers, Super-Smokeless Boilers, Imperial Sectional Boilers, Low Water Line Boilers, Contento Boilers and Gas Boilers.



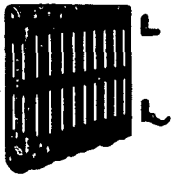
Window Radiator



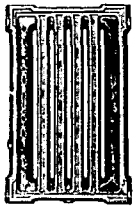
Five-Tube Radiator



Three-Tube Radiator



Legless Radiator



Wall Radiator

Aero Radiation

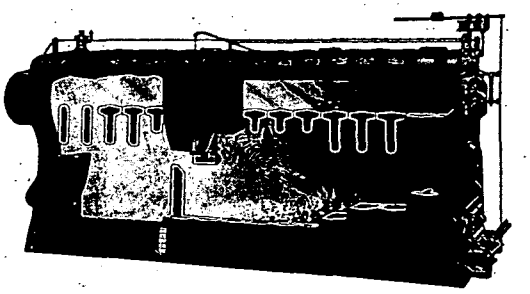
Style—Steam or Water	Distance from Floor to Center of Top Tapping	Height in In.	Square Feet per Section
3 Tube—Width of Section 5⅛"	33⅛ 27⅞ 23⅛ 17⅞	36 30 26 20	3½ 3 2⅝ 1¾
4 Tube—Width of Section 6⅜"	33⅛ 27⅞ 23⅛ 17⅞	36 30 26 20	4¼ 3½ 2¾ 2¼
5 Tube—Width of Section 8⅛"	33⅛ 27⅞ 23⅛ 20⅜ 17⅞	36 30 26 23 20	5 4⅛ 3½ 3 2⅝
6 Tube—Width of Section 9"	35⅞ 29⅞ 23⅞ 20⅝ 17⅞	38 32 26 23 20	6 5 4 3½ 3
7 Tube—Width of Section 12"	33⅛ 27⅞ 23⅛ 17⅞ 14⅛ 11⅜	36 30 26 20 16½ 13½	6¾ 5½ 4¾ 3⅝ 3¼ 2⅝

Floor to center bottom tapping—4½ in. Excepting 13¼ in. and 16½ in. 7 Tube which is 3 in.

National Aero Wall Radiation

Sections Number	Height Inches	Length or Width	Center to Center Tappings	Sq. Ft. Per Section
5A	13⅛	16⅝	10 ⅝	5
7A	13⅛	21⅞	10 ⅝	7
9A	13⅛	29⅛	10 ⅝	9
7B	21⅞	13⅛	18½	7
9B	29⅛	13⅛	25½	9

Thickness of sections—2⅛ in.



National Super-Smokeless Boilers

The patented baffle section separates the primary and secondary combustion chambers. The volatile gases from the coking coal in front are intimately mixed with secondary air and consumed smokelessly. The rotative fire travel scours the flue ways resulting in maximum heat transfer.

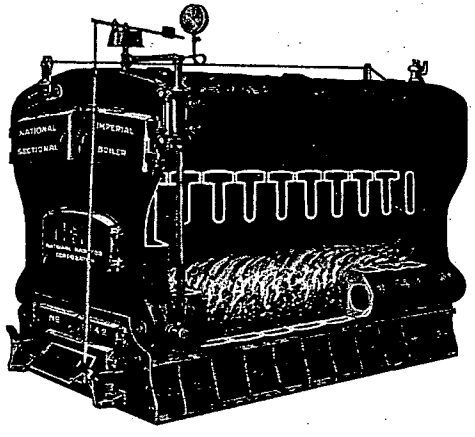
Boiler Number	Steam Rating	Water Rating	Grate Area Sq. Ft.	Length of Sections Only In.	Length of Sections and Smoke Box In.	Number of Outlets Sizes in In.	Chimney Area In.	Chimney Height Ft.	*Boiler Covering Sq. Ft. Surface
24 Series—Height of Water Line, 45½". Height Flow Outlet, 54". Width of Sections—35½".									
245	1600	2600	5.00	37¼	48½	1–4"	12x12	40	34
246	2000	3250	6.25	45½	56¾	2–4"	13x13	40	42
247	2400	3900	7.50	53¾	63½	2–4"	13x13	45	50
248	2800	4550	8.75	62	71½	2–4"	14x14	50	58
249	3200	5200	10.00	70¼	79¾	3–4"	14x14	55	64
33 Series—Height of Water Line, 53". Height Flow Outlet, 64½". Width of Sections—47".									
335	2900	4650	7.32	37¼	49½	1–5"	14x14	40	42
336	3600	5800	9.10	45½	57¾	2–5"	15x15	40	51
337	4300	6950	10.87	53¾	66	2–5"	16x16	40	60
338	5000	8100	12.65	62	72½	2–5"	16x16	50	69
339	5700	9250	14.42	70¼	80¾	3–5"	18x18	50	78
3310	6400	10400	16.20	78½	89	3–5"	18x18	55	87
40 Series—Height of Water Line, 57". Height Flow Outlet, 69". Width of Sections—57½".									
405	4200	6700	9.68	37¼	49¼	1–5"	15x15	50	46
406	5200	8300	12.03	45½	57½	2–5"	16x16	50	50
407	6200	9900	14.38	53¾	65¾	2–5"	18x18	50	66
408	7200	11500	16.73	62	74	3–5"	18x18	55	76
409	8200	13100	19.08	70¼	82¼	3–5"	20x20	55	86
4010	9200	14700	21.43	78½	90½	3–5"	20x20	60	96
4011	10200	16300	23.77	86¾	97	3–5"	21x21	60	106
4012	11200	17900	23.77	95	105¼	4–5"	22x22	65	116
4013	12200	19500	23.77	103¼	113½	4–5"	22x22	70	126
4014	13000	20800	23.77	111½	121¾	4–5"	23x23	75	136
4015	13800	22100	23.77	119¾	130	4–5"	23x23	75	146
4016	14600	23400	23.77	128	138¼	4–5"	24x24	80	156
4017	15400	24700	23.77	136¼	146½	4–5"	24x24	80	166
4018	16200	26000	23.77	144½	154¾	4–5"	25x25	80	176
4019	17000	27300	23.77	152¾	163	5–5"	25x25	85	186
4020	17600	28200	23.77	161	171¼	5–5"	25x25	90	196
4021	18200	29200	23.77	169¼	179½	5–5"	25x25	100	206
4022	18800	30200	23.77	177½	187¾	5–5"	26x26	100	216
4023	19400	31200	23.77	185¾	196	5–5"	27x27	100	226
4024	20000	32200	23.77	194	204¼	5–5"	27x27	100	236

*Square feet of exterior boiler surface. Approximate number of pounds of covering per boiler section, 24 series, 50 lb.; 33 series, 60 lb.; 40 series, 67 lb.

National Duplex Super-Smokeless Boilers

827	13200	21100	28.76	53¾	70¾	1–8"	23x23	60	90
828	15200	24300	28.76	62	79	1–8"	24x24	65	104
829	17200	27500	33.46	70¼	87¼	1–8"	25x25	65	118
8210	19200	30700	33.46	78½	95½	1–8"	26x26	70	132
8211	21200	33900	38.16	86¾	103¾	1–8"	27x27	70	146
8212	23200	37100	38.16	95	112	1–8"	28x28	75	160
8213	25200	40300	42.86	103¼	120¼	1–8"	29x29	80	174
8214	26800	42900	42.86	111½	128½	1–8"	29x29	85	188
8215	28400	45500	42.86	119¾	136¾	1–8"	30x30	85	202
8216	30000	48100	47.54	128	145	1–8"	31x31	90	216
8217	31600	50700	47.54	136¼	153¼	1–8"	32x32	90	230
8218	33200	53300	47.54	144½	161½	1–8"	32x32	90	244

Height of Water Line, 57 in. Height to Center of Outlet, 81½ in. Width of Boiler, 115¼ in.
Regularly furnished with cast iron header, but can be furnished without header when so ordered.
*Square feet of exterior boiler surface. Approximate number of pounds of boiler covering per section, 94 lb.



National Imperial Sectional Boilers

The spacious fire box provides large fuel capacity which allows maximum time between attention periods, and makes it possible to carry an economical and effective fire.

After leaving the combustion chamber the hot gases travel twice the length of the boiler before discharging into the stack.

Special grates can be furnished to burn the smaller sizes of fuel.

Boiler Number	Steam Rating	Water Rating	Grate Area Sq. Ft.	Length of Sections Only In.	Length of Sections and Smoke Box In.	Number of Outlets Sizes in In.	Chimney Area In.	Chimney Height Ft.	*Boiler Covering Sq. Ft. Surface
32 Series—Height of Water Line, 53". Height of Top Outlet, 64½". Width of Boiler, 47".									
532	2900	4650	7.32	37¼	49¾	1–5"	14x14	40	42
632	3600	5800	9.10	45½	58	2–5"	15x15	40	51
732	4300	6950	10.87	53¾	66¼	2–5"	16x16	40	60
832	5000	8100	12.65	62	74¼	2–5"	16x16	50	69
932	5700	9250	14.42	70¼	82½	3–5"	18x18	50	78
42 Series—Height of Water Line, 57". Height of Top Outlet, 69". Width of Boiler, 57½".									
642	5200	8300	12.03	45½	57½	2–5"	16x16	50	56
742	6200	9900	14.38	53¾	65¾	2–5"	18x18	50	66
842	7200	11500	16.73	62	74	3–5"	18x18	55	76
942	8200	13100	19.08	70¼	82½	3–5"	20x20	55	86
1042	9200	14700	21.43	78½	90¾	3–5"	20x20	60	96
1142	10200	16300	23.77	86¾	99	3–5"	21x21	60	106
1242	11200	17900	26.12†	95	107¼	4–5"	22x22	65	116
1342	12200	19500	28.47†	103¼	115½	4–5"	22x22	70	126
1442	13000	20800	30.82†	111½	123¾	4–5"	23x23	75	136
1542	13800	22100	33.17†	119¾	132	4–5"	23x23	75	146
1642	14600	23400	35.52†	128	140¼	4–5"	24x24	80	156

*Square feet of exterior boiler surface. Approximate number of pounds of boiler covering per section—23 series, 50 lb.; 32 series, 60 lb.; 42 series, 67 lb.

†Maximum grate area which can be furnished. Unless otherwise ordered these sizes are shipped with 10 grate bars having a grate area of 23.77 sq. ft.

National Duplex Sectional Boilers

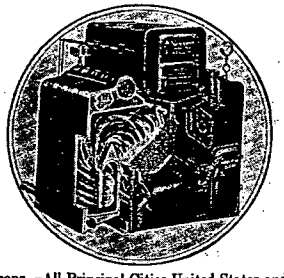
Boiler Number	Steam Rating	Water Rating	Grate Area Sq. Ft.	Length of Sections Only In.	Length of Sections and Smoke Box In.	Number of Outlets Sizes in In.	Chimney Area In.	Chimney Height Ft.	*Boiler Covering Sq. Ft. Surface
684	11200	17900	24.06	45½	62½	1–8"	22x22	65	76
784	13200	21100	28.76	53¾	70¾	1–8"	23x23	65	90
884	15200	24300	33.46	62	79	1–8"	24x24	70	104
984	17200	27500	38.16	70¼	87¼	1–8"	25x25	75	118
1084	19200	30700	38.16	78½	95½	1–8"	26x26	80	132
1184	21200	33900	42.86	86¾	103¾	1–8"	27x27	80	146
1284	23200	37100	42.86	95	112	1–8"	27x27	85	160

Height Water Line, 57 in. Height to Center of Header Outlet, 81¼ in. Width of Boiler, 115¼ in.
Regularly furnished with cast iron header, but can be furnished without header when so ordered.
*Square feet of exterior boiler surface. Approximate number of pounds of boiler covering per section, 94 lb.

Newport Boiler Company

General Offices: 529 S. Franklin St., Chicago

MAGAZINE FEED



OIL BURNING

DISTRIBUTORS—All Principal Cities United States and Canada

This boiler cuts fuel bills from 30 to 50 per cent burning No. 1 Buckwheat coa

"Newport"—alone, provides these Heater essentials:

Convenience Coaling only necessary from once a day to once a week, depending upon the weather. It is therefore the Home Owner's choice.

Economy "Newport" combustion is complete, conforming to all the laws of science. Saves from $5 to $7 per ton, burning No. 1 Buckwheat coal.

Uniform Heat is provided by the never varying thickness of the fuel bed, that supplies heat for every nook and corner, automatically controlled.

Adaptability the patented, adjustable throat, which is water cooled, insures maximum efficiencies, burning all sizes and kinds of coal, coke or oil.

NEWPORT COAL BURNING BOILERS

Boiler Number Steam	Rating Square Feet	*Maximum Direct Radiation Load	Boiler Number Water	Rating Square Feet	*Maximum Direct Radiation Load	Length Overall	Width Overall	Chimney Flue Size Inches	Chimney Flue Height Feet
STEAM			WATER						
S-4	594	340	W-4	1000	572	30¼"	32"	8 x 12	35
S-5	750	430	W-5	1250	714	36½"	32"	8 x 12	35
S-6	907	518	W-6	1500	857	42¾"	32"	8 x 12	40
S-7	1063	607	W-7	1750	1000	49"	32"	12 x 12	40
S-8	1219	696	W-8	2000	1143	55¼"	32"	12 x 12	45
S-55	1375	786	W-55	2282	1304	44"	56"	12 x 12	40
S-66	1688	965	W-66	2782	1590	50¼"	56"	12 x 16	45
S-77	2000	1143	W-77	3313	1893	56½"	56"	12 x 16	45
S-88	2313	1322	W-88	3813	2179	62¾"	56"	16 x 16	50
S-99	2625	1500	W-99	4313	2464	69"	56"	16 x 16	50
S-1010	2938	1679	W-1010	4813	2749	75¼"	56"	18 x 18	50
S-1111	3250	1858	W-1111	5313	3035	81½"	56"	18 x 18	55

NEWPORT OIL BURNING BOILERS

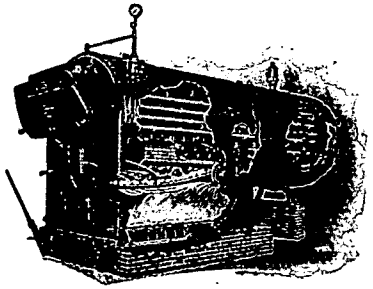
O-S-4	594	340	O-W-4	1000	572	30¼"	32"	8 x 12	35
O-S-5	750	430	O-W-5	1250	714	36½"	32"	8 x 12	35
O-S-6	907	518	O-W-6	1500	857	42¾"	32"	8 x 12	40
O-S-7	1063	607	O-W-7	1750	1000	49"	32"	12 x 12	40
O-S-8	1219	696	O-W-8	2000	1143	55¼"	32"	12 x 12	45
O-S-55	1375	786	O-W-55	2282	1304	44"	56"	12 x 12	40
O-S-66	1688	965	O-W-66	2782	1590	50¼"	56"	12 x 16	45
O-S-77	2000	1143	O-W-77	3313	1893	56½"	56"	12 x 16	45
O-S-88	2313	1322	O-W-88	3813	2179	62¾"	56"	16 x 16	50
O-S-99	2625	1500	O-W-99	4313	2464	69"	56"	16 x 16	50
O-S-1010	2938	1679	O-W-1010	4813	2749	75¼"	56"	18 x 18	50
O-S-1111	3250	1858	O-W-1111	5313	3035	81½"	56"	18 x 18	55

*The "Maximum Direct Radiation Load" is the maximum actual amount of square feet of cast iron column radiation or its equivalent that we recommend be attached to boiler. This amount provides a safety factor of 75 per cent, being ample for average conditions, to take care of the load imposed by mains, risers, etc., but does not provide an allowance for the heating of water for domestic use, or any extra load where attached radiation will condense more than 0.25 (¼) lb. of steam, per square foot per hour.

The water line on all Steam Boilers is 40½ in. Height overall Coal Boilers 62 in. Oil Boilers 48¾ in.

OIL CITY BOILER WORKS Oil City~Pa.

NEW YORK, N. Y., 501 Fifth Ave.
PITTSBURGH, PA., 1116 House Bldg.
ATLANTA, GA., 202 Red Rock Bldg.
BALTIMORE, MD., Whitaker Bldg.
INDIANAPOLIS, IND., 117 East Michigan St.
RICHMOND, VA., American National Bank Bldg.
DETROIT, MICH., 715 Donovan Bldg.
CHICAGO, ILL., 19 W. Jackson Blvd.
LOS ANGELES, CALIF., 1003 Union Trust Bldg.
CHARLOTTE, N. C., 225 Latta Arcade
CINCINNATI, O., S. W. Cor. 3rd and Walnut Sts.
SHREVEPORT, LA., P. O. Box No. 298



"Oil City" Smokeless Boiler

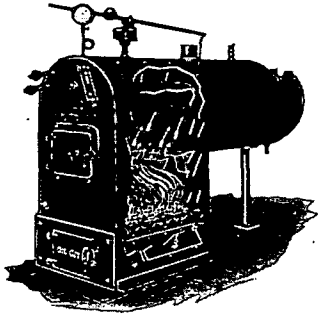
"OIL CITY" low pressure boilers are offered to the trade as the last word in "Heating Economy" comprising in one unit all the elements of a modern plant for steam or hot water heating, especially adapted for Schools, Office Buildings, Hotels, Churches, Club Houses, Hospitals or for any purpose where the service of a universally recognized fire box boiler of high merit is desired.

"OIL CITY" boilers are designed and constructed to meet all requirements of modern engineering as formulated by the *American Society of Mechanical Engineers*, the boiler laws of the various states and cities, and are backed by 35 years of successful practical experience.

Description—"OIL CITY" boilers are built in smokeless and straight draft types for portable and brick settings, self contained with all steel construction thoroughly braced, stayed, inspected, and tested for 15 lb. working pressure.

These boilers have large fire boxes thereby insuring ample combustion space in which heat-giving gases and air freely mix before entering tubes.

The arrangement of tubes in relation to shell allows free circulation of water at all times, together with large steam space, insuring dry steam and steady water level.



"D" Type Boiler

The above view shows the new "D" type residential boiler built in capacities 400 to 2000 sq. ft. direct steam radiation. Send for Circular H-23.

Ratings—Ratings are very conservative, only such parts of the boiler coming in actual contact with passage of the hot gases, and lying below the zone of normal water level being considered as heating surface.

Equipment—Equipment with all boilers includes, in addition to complete set of shaking grates, all the necessary castings, safety valves, steam gauge, water column, etc., required for a complete installation.

Oil Fired—Where oil is used exclusively we recommend our new Series 1900 Portable Return Tubular Fire Box Oil Burning Boiler. Complete specifications and measurements shown in Circular H-22.

Every "OIL CITY" boiler bears the official stamp of the *A. S. M. E.* Boiler Code, indicating the pressure at which the boiler may be worked.

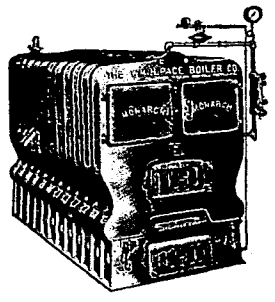
At a small increase in cost "OIL CITY" boilers are furnished, braced and stayed, for a safe working pressure of 100 lb. Complete specifications, measurements and weights shown in Catalog H-9.

The Wm. H. Page Boiler Co.

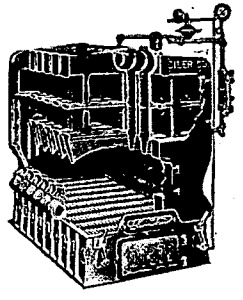
200 Madison Avenue, New York

BOSTON, 123 Beverly Street
BROOKLYN, 98—49th Street
PHILADELPHIA, 1126 Washington Avenue
WASHINGTON, 1117—15th Street, N.W.
CLEVELAND, Rose Building
MEADVILLE, PA., Factory

Makers of Boilers for more than 70 Years



Monarch Smokeless



Monarch Water Tube

Monarch Sectional Steam and Water Boilers

No.	Rating Sq. Ft. Steam	Rating Sq. Ft. Water	‡Size of Grate Inches	‡Full Area of Grate Sq. Ft.	Height Overall Inches Steam	Width Overall Inches Steam	Height Overall Inches Water	Width Overall Inches Water	Length Inches	Water Line Inches Steam	Outlets and Inlets Inches	Size of Smoke Pipe Inches
4-22	850	1400	22 x 20	3.06	59	39¼	52	35	27⅜	41	2-3	13
5-22	1075	1775	22 x 26⅜	4.03	59	39¼	52	35	33⅞	41	2-3	13
6-22	1300	2150	22 x 32¾	5.00	59	39¼	52	35	39⅞	41	2-3	13
7-22	1525	2525	22 x 39⅛	5.98	59	39¼	52	35	46⅜	41	2-3	13
4-28	1600	2650	28 x 24¼	4.82	70½	45¼	62¾	41	35⅜	51	2-5	16
5-28	2100	3475	28 x 33⅛	6.45	70½	45¼	62¾	41	43⅝	51	2-5	16
6-28	2600	4300	28 x 41⅞	8.07	70½	45¼	62¾	41	51¾	51	2-5	16
7-28	3100	5125	28 x 49⅞	9.70	70½	45¼	62¾	41	60¼	51	2-5	16
8-28	3600	5950	28 x 58¼	11.32	70½	45¼	62¾	41	69	51	2-5	16
9-28	4100	6775	28 x 66⅝	12.96	70½	45¼	62¾	41	77⅛	51	2-5	16
5-40	3400	5600	40 x 33⅛	9.20	80	59⅛	72½	55	43⅜	58	2-5	21
6-40	4200	6925	40 x 41½	11.52	80	59¼	72½	55	51¾	58	2-5	21
7-40	5000	8250	40 x 49⅞	13.85	80	59¼	72½	55	60¼	58	2-5	21
8-40	5800	9575	40 x 58¼	16.18	80	59¼	72½	55	69	58	2-5	21
9-40	6600	10,900	40 x 66⅝	18.50	80	59¼	72½	55	77⅛	58	2-5	21
10-40	7400	12,200	40 x 75	20.82	80	59¼	72½	55	85¼	58	2-5	21
11-40	8200	13,525	40 x 83⅜	23.13	80	59¼	72½	55	94	58	3-5	21
12-40	9000	14,850	40 x 91¾	25.50	80	59¼	72½	55	101⅞	58	3-5	21
6-60	6600	10,900	60 x 41½	17.29	81½	86¼	74¼	82	51¾	60	2-6	26
7-60	8200	13,525	60 x 49⅞	20.78	81½	86¼	74¼	82	60¼	60	2-6	26
8-60	9800	16,175	60 x 58¼	24.27	81½	86¼	74¼	82	69	60	2-6	26
9-60	11,400	18,800	60 x 66⅝	27.76	81½	86¼	74¼	82	77⅛	60	3-6	26
10-60	13,000	21,450	60 x 66⅝	‡31.25	81½	86¼	74¼	82	85¼	60	3-6	26
11-60	14,600	24,100	60 x 66⅝	‡34.74	81½	86¼	74¼	82	94	60	3-6	26
12-60	16,200	26,725	60 x 75	‡38.22	81½	86¼	74¼	82	101⅞	60	3-6	26
13-60	17,800	29,375	60 x 75	‡41.72	81½	86¼	74¼	82	110¼	60	3-6	26
14-60	19,400	32,000	60 x 75	‡45.20	81½	86¼	74¼	82	118¾	60	3-6	26
15-60	21,000	34,650	60 x 83⅜	‡48.69	81½	86¼	74¼	82	127½	60	3-6	26
16-60	22,600	37,300	60 x 83⅜	‡52.18	81½	86¼	74¼	82	135⅝	60	3-6	26
17-60	24,200	39,950	60 x 83⅜	‡55.67	81½	86¼	74¼	82	143¾	60	3-6	26
18-60	25,800	42,600	60 x 91¾	‡59.16	81½	86¼	74¼	82	152⅛	60	3-6	26
19-60	27,400	45,200	60 x 91¾	‡62.65	81½	86¼	74¼	82	160⅞	60	3-6	26
20-60	29,000	47,850	60 x 91¾	‡66.14	81½	86¼	74¼	82	168¾	60	3-6	26

Ratings, as given, are derived from tests made in accordance with the AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS' Low-Pressure Boiler Testing Code.

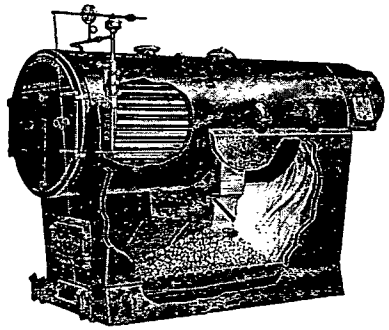
‡Grate areas are for entire length of firebox, but, unless otherwise ordered, these boilers will be shipped with bridgewall section to reduce grate to length in table of dimensions above.

Pacific Steel Boiler Corporation

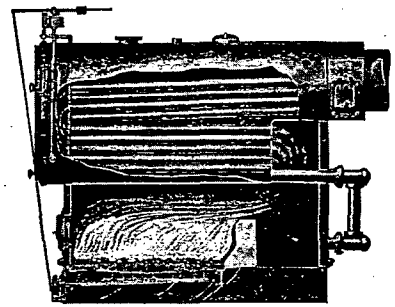
Manufacturers of

Pacific Steel Heating Boilers, Pacific Circulating Tanks

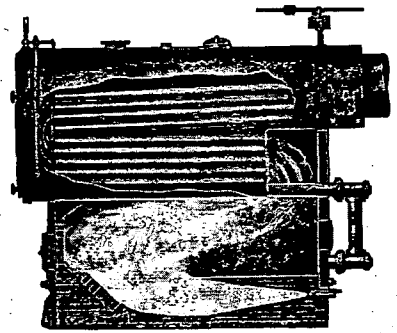
Waukegan, Illinois and Bristol, Pennsylvania



For Burning Soft Coal Smokelessly



For Soft or Hard Coal, Gas or Wood



For Burning Oil

P A C I F I C

STEEL HEATING BOILERS

Pacific Steel Heating Boilers are built for steam or hot water heating using soft coal, hard coal, oil, gas, or wood as fuel.

They are constructed of steel according to the *A. S. M. E.* Code for building low pressure steel heating boilers. Every joint and seam in the Pacific is electrically welded and each boiler is built and tested to a pressure many times its normal working pressure under the supervision of an inspector stationed in our plant by one of the largest insurance companies.

Because of the compact design, Pacific Boilers save from 25 to 40 per cent. of the boiler room floor space required by other steel firebox boilers, (see dimensions given on opposite page).

The catalog ratings on Pacific Boilers are based on heating surface with steam at two pounds gauge pressure, hot water at 180 deg. at boiler. Any Pacific Boiler will carry its full rated load in direct cast iron radiation. Extra capacity must be allowed for exposed piping, storage tank, pipe coils or indirect radiators and for buildings where normal temperatures below 70 deg. F. are to be maintained.

PACIFIC SMOKELESS BOILERS

Catalogue Number	Net Rating	Height Water Line, Inches	Diameter Smoke Connec. Inches	Diameter Stack Inches	Minimum Height Stack, Feet	Grate Area, Square Feet	Heating Surface, Square Feet	Size of Outlet, Inches	Size of Return, Inches	Length Overall	Width Overall	Height Boiler	Length Base	Width Base	Height Base	Length for Ashpit	Width for Ashpit	Depth for Ashpit
6608	1400	61	14	13	55	6.5	131.4	5	3	62½	39	72½	46½	36	12	25	30	NOT LESS THAN SIX INCHES
6609	1650	61	14	13	55	6.5	149.0	5	3	68½	39	72½	52½	36	12	25	30	
6610	1900	61	14	13	55	7.3	166.6	5	3	74½	39	72½	58½	36	12	29	30	
6611	2150	61	14	13	60	8.1	184.2	5	3	80½	39	72½	64½	36	12	33	30	
6612	2400	61	14	13	60	9.0	201.8	5	3	86½	39	72½	70½	36	12	37	30	
6613	2800	68½	17	16	60	10.2	232.8	6	3	77½	43½	81½	58½	40¾	12	37	34¾	
6614	3400	68½	17	16	60	11.1	283.2	6	3	89½	43½	81½	70½	40¾	12	41	34¾	
6615	4000	68½	17	16	60	12.0	333.6	6	3	101½	43½	81½	82½	40¾	12	45	34¾	
614	4500	68½	18	17	60	12.70	372.0	6	3	106	49¼	79¼	88½	38	12	53	32	
615	5000	75½	18	17	60	12.07	392.0	6	3	96	58	89¼	76½	44	12	41	38	
616	5500	75½	18	17	65	13.10	425.0	6	3	102	58	89¼	82½	44	12	45	38	
617	5800	75½	18	17	65	15.15	457.6	6	3	108	58	89¼	88½	44	12	53	38	
618	6500	82¼	24	22	65	16.42	508.5	8	4	98	62½	96	76½	50½	12	49	44½	
619	7500	82¼	24	22	70	18.83	594.8	8	4	110	62½	96	88½	50½	12	57	44½	
620	8500	82¼	24	22	70	20.00	637.5	8	4	116	62½	96	94½	50½	12	61	44½	
621	9000	89½	26	24	70	19.11	708.7	8	4	112½	70½	106	88½	57½	12	49	51½	
622	10000	89½	26	24	75	20.50	809.5	8	4	124½	70½	106	100½	57½	12	53	51½	
623	12000	99½	30	28	75	25.14	864.5	8	4	113½	77½	117¾	88½	64	15	61	58	
624	14000	99½	30	28	75	26.64	988.8	8	4	125½	77½	117¾	100½	64	15	65	58	
625	15500	106	32	30	85	32.60	1183.8	8	5	127	86	125¾	100½	83½	15	57	77½	
626	18000	106	32	30	85	34.70	1332.9	8	5	139	86	125¾	112½	83½	15	61	77½	
627	20500	106	32	30	90	36.80	1482.0	10	6	151	86	125¾	124½	83½	15	65	77½	
628	22000	119	36	33	100	39.10	1583.1	10	6	144½	95½	140	113½	96½	18	61	90½	
629	25000	119	36	33	100	41.40	1759.0	10	6	156½	95½	140	125½	96½	18	65	90½	
630	28000	119	36	33	100	43.70	1934.9	10	6	168½	95½	140	137½	96½	18	69	90½	

For Pacific Oil Fired Boilers use the above specification.

PACIFIC DIRECT DRAFT BOILERS

Catalogue Number	Net Rating	Height Water Line, Inches	Diameter Smoke Connec. Inches	Diameter Stack Inches	Minimum Height Stack, Feet	Grate Area, Square Feet	Heating Surface, Square Feet	Size of Outlet, Inches	Size of Return, Inches	Length Overall	Width Overall	Height Boiler	Length Base	Width Base	Height Base	Length for Ashpit	Width for Ashpit	Depth for Ashpit
2208	1200	61	14	13	50	6.5	131.4	5	3	62½	39	72½	46½	36	12	25	30	NOT LESS THAN SIX INCHES
2209	1400	61	14	13	50	6.5	149.0	5	3	68½	39	72½	52½	36	12	25	30	
2210	1600	61	14	13	50	7.3	166.6	5	3	74½	39	72½	58½	36	12	29	30	
2211	1800	61	14	13	55	8.1	184.2	5	3	80½	39	72½	64½	36	12	33	30	
2212	2000	61	14	13	55	9.0	201.8	5	3	86½	39	72½	70½	36	12	37	30	
2213	2350	68½	17	16	55	10.2	232.8	6	3	77½	43½	81½	58½	40¾	12	37	34¾	
2214	2850	68½	17	16	55	11.1	283.2	6	3	89½	43½	81½	70½	40¾	12	41	34¾	
2215	3350	68½	17	16	55	12.0	333.6	6	3	101½	43½	81½	82½	40¾	12	45	34¾	
214	3800	68½	18	17	55	12.70	372.0	6	3	106	49¼	79¼	88½	38	12	53	32	
215	4100	75½	18	17	55	12.07	392.0	6	3	96	58	89¼	76½	44	12	41	38	
216	4500	75½	18	17	60	13.10	425.0	6	3	102	58	89¼	82½	44	12	45	38	
217	5000	75½	18	17	60	15.15	457.6	6	3	108	58	89¼	88½	44	12	53	38	
218	5500	82¼	24	22	60	16.42	508.5	8	4	98	62½	96	76½	50½	12	49	44½	
219	6500	82¼	24	22	65	18.83	594.8	8	4	110	62½	96	88½	50½	12	57	44½	
220	7000	82¼	24	22	65	20.00	637.5	8	4	116	62½	96	94½	50½	12	61	44½	
221	7500	89½	26	24	65	19.11	708.7	8	4	112½	70½	106	88½	57½	12	49	51½	
222	8500	89½	26	24	70	20.50	809.5	8	4	124½	70½	106	100½	57½	12	53	51½	
223	10000	99½	30	28	70	25.14	864.5	8	4	113½	77½	117¾	88½	64	15	61	58	
224	11500	99½	30	28	70	26.64	988.8	8	4	125½	77½	117¾	100½	64	15	65	58	
225	13000	106	32	30	75	32.60	1183.8	8	5	127	86	125¾	100½	83½	15	57	77½	
226	15000	106	32	30	75	34.70	1332.9	8	5	139	86	125¾	112½	83½	15	61	77½	
227	17000	106	32	30	80	36.80	1482.0	10	6	151	86	125¾	124½	83½	15	65	77½	
228	19000	119	36	33	90	39.10	1583.1	10	6	144½	95½	140	113½	96½	18	61	90½	
229	22000	119	36	33	90	41.40	1759.0	10	6	156½	95½	140	125½	96½	18	65	90½	
230	25000	119	36	33	90	43.70	1934.9	10	6	168½	95½	140	137½	96½	18	69	90½	

Pacific Boilers are constructed with smoke outlet at the rear and all of the tubes, both upper and lower banks, are cleaned or removed from the front of the boiler through the front flue doors. Space at rear of boiler is not necessary.

Complete catalog showing all types and sizes Pacific Boilers will be furnished on request.

Pierce Firebox Boilers

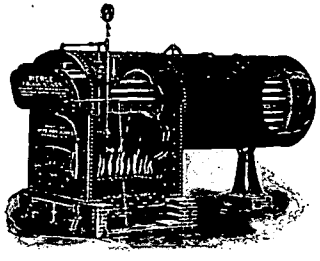
Built by

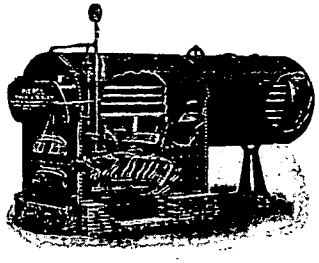
AMES IRON WORKS

Division of

Pierce, Butler & Pierce Manufacturing Corporation

OSWEGO, N. Y.





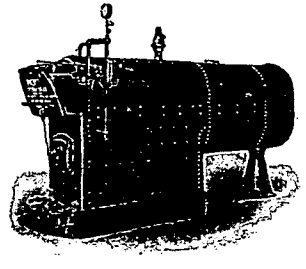
STEEL FIREBOX HEATING BOILERS

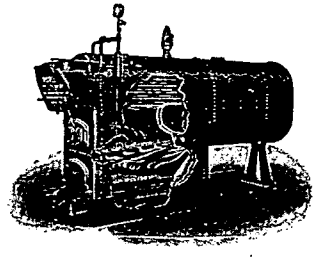
are built to comply with *A.S.M.E.* Code requirements

Their capacities range from 2000 to 30,000 sq. ft. direct cast iron column radiation. These boilers are of **riveted construction** for 15, 100 or 125 lb. steam pressure, or **all welded construction** for 15 lb. steam pressure. With **plain furnace** suitable for oil or anthracite coal or **downdraft furnace** for bituminous coal.

The Company has established an enviable reputation and for 75 years have been building High Pressure Horizontal Tubular, Portable, Locomotive, Upright and Empire Boilers as well as all types of Steam Engines.

Send for Bulletins to obtain detail Specifications and Dimensions





Pierce, Butler & Pierce Mfg. Corp.

41 East 42nd Street, **New York City**

Factories

EASTWOOD AND OSWEGO, N. Y.; HUNTINGDON, PA.; ZANESVILLE, OHIO

Branch Offices and Show Rooms

AKRON, OHIO	DOVER, N.J.	NEW LONDON, CONN.	RICHMOND, VA.
BALTIMORE, MD.	FOREST HILLS, N.Y.	NEW YORK, N.Y.	ROANOKE, VA.
BOSTON, MASS.	JACKSONVILLE, FLA.	PHILADELPHIA, PA.	SAVANNAH, GA.
CLEVELAND, OHIO	NEWARK, N.J.	PITTSBURGH, PA.	SYRACUSE, N.Y.
DETROIT, MICH.	NEW HAVEN, CONN.	PROVIDENCE, R.I.	WORCESTER, MASS.

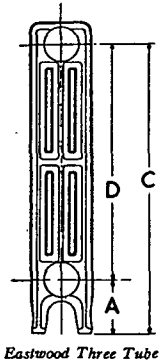
PRODUCTS

Cast iron water boilers 100 to 23,450 sq. ft. capacity. Cast iron steam boilers 325 to 14,200 sq. ft. capacity. Firebox heating boilers, capacity steam radiation 2,500 to 25,000 sq. ft.; capacity water radiation 4,000 to 40,000 sq. ft. Radiators —all types; Radiator Valves, High Pressure Valves, Hot Water Valves, Hot Water Thermometers, Pressure and Altitude Gages

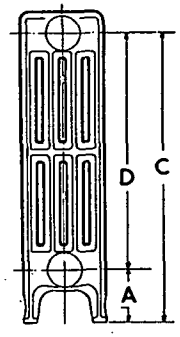
Pierce Eastwood Screw Nipple Radiator

NOTE the generous dimensions—particularly the width of the sections. The so-called "square feet," the units in which radiators are sold, are correspondingly generous in size.

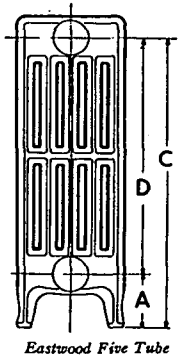
In the seven-tube series, the sections are spaced on 3-in. centers instead of 2½ in., as in the narrower patterns. This extra spacing preserves the effect of lightness and grace in the largest radiators. It also measurably increases the heating effect.



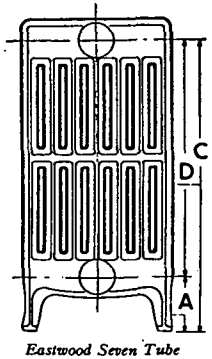
Eastwood Three Tube



Eastwood Four Tube



Eastwood Five Tube



Eastwood Seven Tube

Width of Section, 5⅛ in.				Width of Section, 7 in.				Width of Section, 8⅞ in.				Width of Section, 12⅞ in.			
Length of Section in Stack, 2½ in.				Length of Section in Stack, 2½ in.				Length of Section in Stack, 2½ in.				Length of Section in Stack, 3 in.			
Height In.	A In.	C In.	D In.	Height In.	A In.	C In.	D In.	Height In.	A In.	C In.	D In.	Height In.	A In	C In.	D In.
38	4½	36¼	31¾	38	4½	36¼	31¾	38	4½	36¼	31¾	38	4½	36¼	31¾
32	4½	30¼	25¾	32	4½	30¼	25¾	32	4½	30¼	25¾	32	4½	30¼	25¾
26	4½	24¼	19¾	26	4½	24¼	19¾	26	4½	24¼	19¾	26	4½	24¼	19¾
20	4½	18¼	13¾	20	4½	18¼	13¾	22	4½	20¼	15¾	22	4½	20¼	15¾
								20	4½	18¼	13¾	17	4½	15¼	10¾
												14	4½	12¼	7¾

Richardson & Boynton Co.

Manufacturers of "Richardson" "Perfect" Heating and Cooking Apparatus since 1837

260 Fifth Avenue, **New York City**

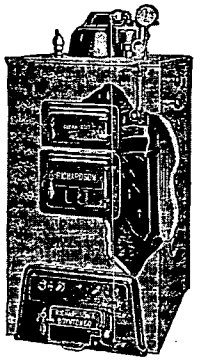
NEW YORK UTICA NEWARK PHILADELPHIA BOSTON CHICAGO BUFFALO
MINNEAPOLIS CINCINNATI PITTSBURGH DETROIT PROVIDENCE

New "RICHARDSON" Square Cased Boilers

Finish.—The outer casing is finished with high lustre blue Japan that is durable, easy to clean and will not crack or peel. The doors, ashpit front and smokebox, in other words, all cast iron parts not covered by the casing are coated with black enamel.

Insulation.—The lining or insulation of the "Richardson" boiler is of 1 in. 8-ply asbestos air cell and is attached to the cases when shipped. It thus cannot be damaged in transit or in handling. The air space between the heating unit and the outer casing provides extra heat conserving insulation.

Casings.—The casings are cut in half from side to side at the flow openings on the top of the boiler and horizontally at the return tappings so that they can be attached after all piping connections to the boiler are made.



Sectional View of "Richardson" Square Cased Boiler showing round interior construction, extra air space insulation and heavy asbestos insulation on outer casing.

RICHARDSON SQUARE CASED BOILER

Steam		Water		Grate area, sq. ft.	Diam. of grate, in.	Height, in.		Water line, stm., in.	Smoke pipe, in.	Square of base, in.	Outlets, in.	
No.	Rating, sq. ft.	No.	Rating, sq. ft.			Water	Steam				Steam	Water
1-S-1	350	1-W-1	550	1.58	17	43	49¾	44¼	7	26¾	2—2½	2—2½
1-S-2	425	1-W-2	675	1.58	17	47	53¾	48½	7	26¾	2—2½	2—2½
1-S-3	550	1-W-3	850	2.18	20	43¾	50½	45¼	8	29¾	2—3	2—3
1-S-4	650	1-W-4	1050	2.18	20	47¾	54½	49½	8	29¾	2—3	2—3
1-S-5	800	1-W-5	1350	2.89	23	46¼	53½	48¼	9	32¾	2—3	2—3
1-S-6	900	1-W-6	1500	2.89	23	50¼	57½	52½	9	32¾	2—3	2—3
1-S-7	1050	1-W-7	1700	3.70	26	47	55	49½	10	36¼	2—3½	2—3½
1-S-8	1150	1-W-8	1900	3.70	26	51	59	53¾	10	36¼	2—3½	2—3½

"Richardson" System of Mechanical Warm Air Heating and Ventilating

The Richardson System of Mechanical Heating and Ventilating provides a predetermined volume of fresh, warmed, moist air uniformly throughout the space to be heated. This system is especially suitable for the heating and ventilating of schools, churches, auditoriums, large residences, hospitals, garages, manufacturing plants, and is applicable to commercial enterprises where drying is to be done.

Heat is evenly distributed to all parts of the building at the proper temperature, and a healthful air condition is also maintained at all times without drafts, summer as well as winter, irrespective of the outside temperature conditions or direction of the winds.

This system is customarily installed with a sufficient capacity to provide from three to seven changes of air to each room per hour, depending on the type of the building and the number of people occupying the space to be heated.

By means of the Richardson System entire buildings can be warmed within 90 minutes from the time the heaters are put in operation.

How the System Works—The Richardson System of Mechanical Heating and Ventilating consists of warm air heaters (designed for this purpose) with fans or blowers.

Fresh outdoor air is drawn from a fresh air room by a fan into the plenum or pressure chamber back of the "Perfect" Warm Air Heaters; from here the air is passed over the prime heating surface of the heater which is set in a galvanized or brick housing known as the heat chamber, and thoroughly warmed. The air is then forced through ducts and discharged into the various rooms through grilles or registers located about 8 ft. above the floor level or placed in or just above the floor as may be necessary, according to the adaptability of the house or building to be heated, thus assuming the control of the movement of all air to the rooms connected to the system.

The vitiated or cooled air in the rooms is exhausted (to make space for the fresh warmed air) into vent stacks through grilles at the floor line, fitted with louvers, or slatted and highly sensitive metal panels, which prevent back-drafts.

L. J. Mueller Furnace Co.

Manufacturers and Western Distributors

200 Reed Street, **Milwaukee, Wis.**

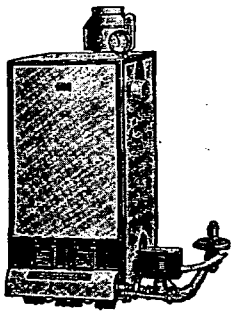
Richardson & Boynton Co.

Eastern Distributors

260 Fifth Avenue, **New York, N. Y.**

Gas-Era Gas-Fired Boiler

Adaptable for steam or hot water heating. Completely automatic operation. Cast iron construction for durability, with asbestos-lined metallic jacket. Vertical burner adjustment permits use with any manufactured or natural gas. Have steady water line and will not prime. Interior surfaces may be thoroughly cleaned without disturbing jacket. Multiple unit construction permits increase in size when desired. Boiler is highly efficient securing maximum heat utilization with minimum gas consumption.



Gas-Era Boiler

STEAM		WATER		STEAM		WATER	
Boiler No.	*A.G.A.* Rating	Boiler No.	*A.G.A.* Rating	Boiler No.	*A.G.A.* Rating	Boiler No.	*A.G.A.* Rating
13-S	420	13-W	670	1327-S	5460	1327-W	8710
25-S	840	25-W	1340	1429-S	5880	1429-W	9380
37-S	1260	37-W	2010	1531-S	6300	1531-W	10050
49-S	1680	49-W	2680	1634-S	6720	1634-W	10720
511-S	2100	511-W	3350	1838-S	7560	1838-W	12060
613-S	2520	613-W	4020	2042-S	8400	2042-W	13400
715-S	2940	715-W	4690	2246-S	9240	2246-W	14740
817-S	3360	817-W	5360	2450-S	10080	2450-W	16080
919-S	3780	919-W	6030	2654-S	10920	2654-W	17420
1021-S	4200	1021-W	6700	2858-S	11760	2858-W	18760
1123-S	4620	1123-W	7370	3062-S	12600	3062-W	20100
1225-S	5040	1225-W	8040				

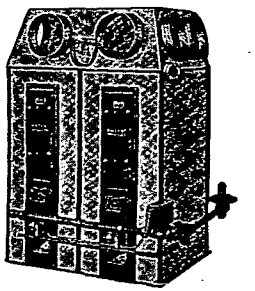
Standard Equipment with all Boilers. Insulated metallic jacket, draft hood, gas pressure regulator, electric gas valve, safety pilot, main gas cock, pilot gas cock, draw-off cock, cleaning brush. Steam boilers have automatic steam and vapor pressure regulator and low water cut-off, water gauge and try cocks, retard steam gauge and pop safety valve. Water boilers have automatic water temperature regulator, altitude gauge and thermometer.

Gas-Era Gas-Fired Warm Air Furnace

Cast iron construction, with lacquered casing in attractive color. Completely automatic, tamper-proof operation. Burns any gas, natural or manufactured. Accessible for cleaning. Ample free area. Automatic moisture supply. Adaptable for forced air heating on large jobs. Multiple unit construction.

Furnace No.	*A.G.A.* Input Rating B.t.u per Hour	Total Load B.t.u per Hour	Capacity Warm Air Pipes Sq. In.
1 (10)*	65,000	47,500	430
2 (20)	130,000	95,000	860
3 (30)	195,000	142,500	1290
4 (40)	260,000	190,000	1720
5 (50)	325,000	237,500	2150
6 (60)	390,000	285,000	2580

*Same furnace, less electrical equipment and automatic humidifier.
Data on larger units on application.



Gas-Era Furnace

RICHMOND RADIATOR COMPANY

INCORPORATED

Executive Office

1480 Broadway, New York

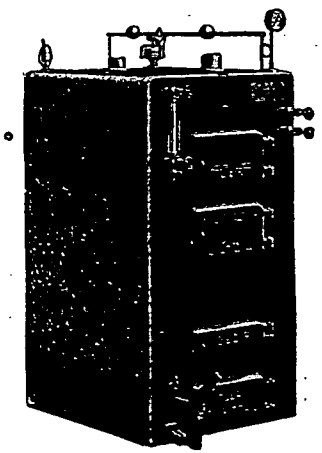
Branch Offices

CHICAGO, 1010 Wrigley Building
BOSTON, 460 Park Square Building
PHILADELPHIA, 2241 North American St.
CLEVELAND, Cedar Avenue and Ashland Road

Gas Boiler Division: 2220 Chestnut Street, Philadelphia, Pa.

Radiator, Enameldware and Heatomat Plant, Uniontown, Pa.

Boiler Plant, Norwich, Conn.



"RICHMOND-MODEL"

INSULATED AND JACKETED SECTIONAL BOILER

STEAM AND WATER

Available with or without smoke preventing device, made in three widths of grates, 15 in., 22 in. and 36 in.

Catalog containing ratings, measurements, etc., sent on request.

RICHMOND HEATOMAT GAS BOILER

For efficiency, simplicity, and construction in accordance with soundest principles of engineering

Engineering skill and an exacting construction policy have produced in the RICHMOND Heatomat, a Gas Boiler that translates 85 per cent of the fuel value into heat. Made for Steam, Hot Water, or Vapor Systems—to be used in small or large houses, office buildings, hotels and apartment houses.

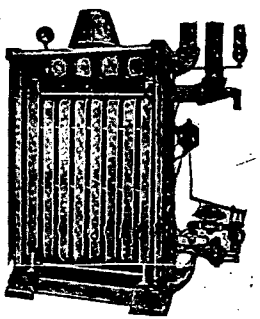
The Heatomat is modeled along the lines of the larger power plant boilers combining efficiency with utmost simplicity.

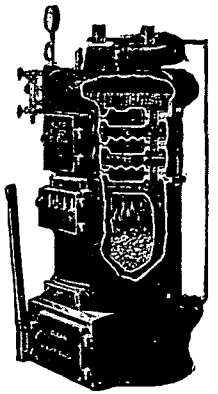
The entire line of RICHMOND Heatomat Gas Boilers is approved by the American Gas Association for efficiency and safety of operation.

The RICHMOND Heatomat catalog includes data on cost of gas boiler operation versus coal. Also complete description of exclusive mechanical features sizes, ratings, cost, etc.

Outstanding features of the Heatomat

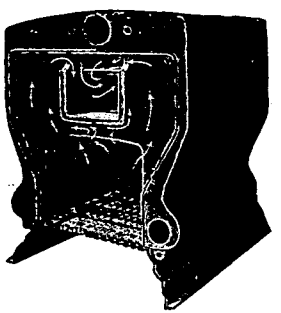
Vertical Tubular Construction.
Preheating return water flow with flue gas heat.
Water cooled walls absorb burner heat.
Secondary air intake regulated with gas flow.
Heat transmission scientifically baffled.
Only one burner, one primary air setting for battery.





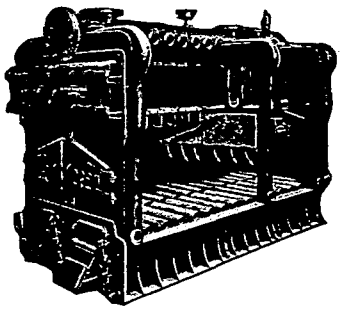
"Richmond" Round

Official tests credit this boiler with a greater heating surface and efficiency than others of equal diameter and number of sections. Made for Steam and Hot Water in eighteen sizes.



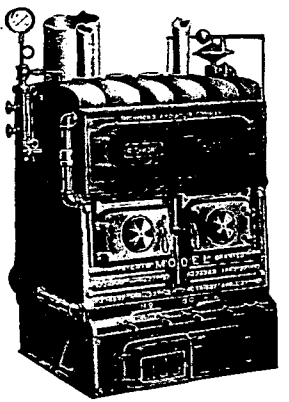
"Richmond" 25 and 36 in. Sectional Boilers

Burn Hard and Soft Coal, Coke, Gas and Fuel Oils. Incorporates a maximum of direct fire surface, quick internal circulation and rapid flow of water. For Steam, Vapor, Vacuum and Hot Water Heating.



"Richmond" Heavy Duty Smokeless Boilers

Designed for Fuel Economy. Burns all grades of Hard or Soft Coal, Coke, Lignite, Natural Gas and Fuel Oils. Meets the requirements of the most rigid Smoke Ordinances. A 51 in. Boiler, 7 to 16 Sections, Steam and Hot Water.



Model Sectional Boilers

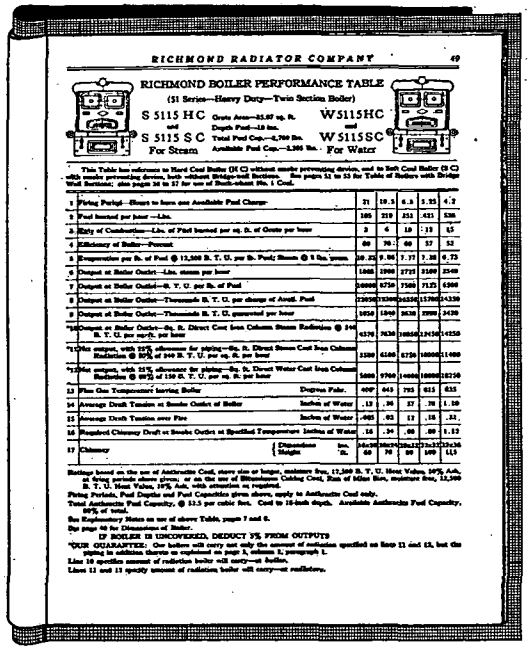
For Steam and Hot Water. Three to twelve sections, 18, 22, 30 and 40 in. grates. Compact, accessible, efficient heating surface and circulation system.

"THE RICHMOND ENGINEERING DATA BOOK"

is filled with helpful information

Engineers!! Architects!! Heating Contractors!! will find "The RICHMOND Data Book" a useful and dependable member of their engineering and estimating Staff.

It is Original—Authoritative—Helpful—and gives the answer to boiler selection problems.



RICHMOND RADIATOR COMPANY 49

RICHMOND BOILER PERFORMANCE TABLE

(51 Series—Heavy Duty—Twin Section Boiler)

S 5115 HC and S 5115 SC For Steam — W 5115 HC and W 5115 SC For Water

Grate Area—15.07 sq. ft. Depth Pool—18 ins. Total Fuel Cap.—4,700 lbs. Available Fuel Cap.—2,585 lbs.

This Table has reference to Hand Coal Boiler (H C) without smoke preventing device, and to Soft Coal Boiler (S C) with smoke preventing device, both without Bridge-wall Section. See pages 51 to 53 for Table of Boilers with Bridge Wall Section; also pages 54 to 57 for use of Fresh-reburn fire, 1 Coal.

1	Firing Period—Hours to burn one Available Fuel Charge	21	10.5	6.3	3.35	4.7
2	Fuel burned per hour —Lbs.	185	319	251	431	536
3	Rate of Combustion—Lbs. of Fuel burned per sq. ft. of Grate per hour	3	4	10	13	15
4	Efficiency of Boiler—Percent	80	70	60	57	52
5	Evaporation per lb. of Fuel @ 12,500 B. T. U. per lb. Fuel; Steam @ 5 lbs. press.	10.32	9.66	7.77	7.38	6.72
6	Output at Boiler Outlet—Lbs. steam per hour	1868	3066	2725	3169	3548
7	Output at Boiler Outlet—B. T. U. per lb. of Fuel	23350	38330	34060	39610	44350
8	Output at Boiler Outlet—Thousands B. T. U. per charge of Avail. Fuel	42030	68390	54530	71060	79410
9	Output at Boiler Outlet—Thousands B. T. U. guaranteed per hour	1868	3066	2725	3169	3548
*10	Output at Boiler Outlet—Sq. ft. Direct Cast Iron Column Steam Radiation @ 240 B. T. U. per sq.ft. per hour	4370	7138	11362	13208	14783
*11	Min. output, with 10% allowance for piping—Sq. ft. Direct Steam Cast Iron Column Radiation @ 80% of 240 B. T. U. per sq. ft. per hour	3369	5505	8756	10186	11400
*12	Min. output, with 10% allowance for piping—Sq. ft. Direct Water Cast Iron Column Radiation @ 80% of 150 B. T. U. per sq. ft. per hour	5608	9166	14584	16966	18990
13	Flue Gas Temperature leaving Boiler Degrees Fahr.	600°	645	705	815	855
14	Average Draft Tension at Smoke Outlet of Boiler Inches of Water	.12	.26	.37	.70	1.10
15	Average Draft Tension over Fire Inches of Water	.025	.05	.12	.18	.32
16	Required Chimney Draft at Smoke Outlet at Specified Temperature Inches of Water	.16	.34	.66	.89	1.22
17	Chimney {Diameter Inside / Height}	16x20 / 60	20x24 / 70	24x28 / 80	32x32 / 100	32x36 / 115

Ratings based on the use of Anthracite Coal, above size or larger, Buckwheat Size, 17,500 B. T. U. Heat Value, 10% Ash, as fired, periods shown given, or on the use of Bituminous Coking Coal, Run of Mine Size, Moderate Ash, 13,500 B. T. U. Heat Value, 15% Ash, with attendance as required.

Firing Periods, Fuel Depths and Fuel Capacities given above, apply to Anthracite Coal only.

Total Anthracite Fuel Capacity, @ 53.5 per cubic foot. Coal to 18-inch depth. Available Anthracite Fuel Capacity, 55% of total.

See Explanatory Notes on use of above Table, pages 7 and 8.

For pages to be Discontinued, see below.

IF BOILER IS UNCOVERED, DEDUCT 5% FROM OUTPUTS

*OUR GUARANTEE: Our boilers will carry not only the amount of radiation specified on lines 11 and 12, but the piping in addition, thereto as explained on page 3, subhead 1, paragraph 1.

Line 10 specifies amount of radiation boiler will carry—at Boiler.

Lines 11 and 12 specify amount of radiation boiler will carry—at radiators.

Men who specify and buy boilers have need of such a book as this and RICHMOND has compiled it.

In addition to the volume of engineering information it includes, there is a performance data page similar to the one shown, for every RICHMOND Boiler, round and square. The page reproduced is the detailed performance table of the RICHMOND Heavy Duty Boiler illustrated on the second preceding page. Such data based upon Official Codes are a dependable guide for Engineers, Architects and Contractors in the selection of a boiler that will perform most efficiently and economically.

Contents

Below is a skeleton list of the contents of "The RICHMOND Engineering Data Book:"

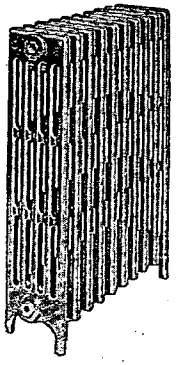
Foreword.
Standard Requirements.
Explanatory Notes Regarding Performance Tables.
Dimensions, etc., of Round Boiler.
Guarantee of Ratings.
A. S. M. E. Boiler Construction Code.
A. S. H. & V. E. Boiler Testing Code.
Heating and Piping Contractors' Formula for Output Tests.
A. S. H. & V. E. Formula for computing Radiation.
Heating and Piping Contractors' National Association's Formula for computing Radiation.
Buckwheat Coal Grates for Boilers.
Boiler and Pipe Covering.
Chimney Data.

Richmond Boilers are Code Boilers

All RICHMOND Boilers are Built, Tested, Rated and Ratings Certified according to the official interpretation of Standard Codes. *Ratings are based upon exact boiler outputs*—that is, the exact amount of direct cast iron column radiation boilers will carry in addition to piping uncovered, boiler only covered.

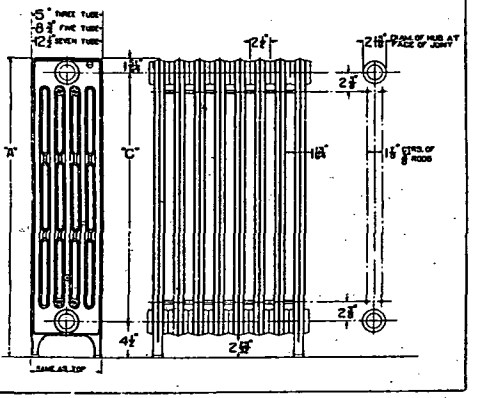
Sent upon Request

Address our Executive Office or nearest Branch Office for copy of "The RICHMOND Engineering Data Book."



'RICHMOND' TUBE RADIATION

PUSH NIPPLE CONSTRUCTION



The "RICHMOND"

A masterpiece of design. Greater heating surface and space between sections. No protruding surfaces. Tested at Frost Laboratories in accordance with code of A. S. H. & V. E. Three, five and seven tubes, in several heights.

No. of Sections	38-Inch 3-Tube A Catalog Rating Sq. Ft. Per Sec.	38-Inch 3-Tube B Sq. Ft. Per Rad. Equiv. Surface at 240 B.t.u. Per Sq. Ft.	38-Inch 5-Tube A Catalog Rating Sq. Ft. Per Sec.	38-Inch 5-Tube B Sq. Ft. Per Rad. Equiv. Surface at 240 B.t.u. Per Sq. Ft.	20-Inch 7-Tube A Catalog Rating Sq. Ft. Per Sec.	20-Inch 7-Tube B Sq. Ft. Per Rad. Equiv. Surface at 240 B.t.u. Per Sq. Ft.
1	3¼	5.40	5	8.93	3¾	6.32
2	6½	8.79	10	14.22	7½	10.22
3	9¾	12.17	15	19.51	11¼	14.12
4	13	15.56	20	24.80	15	18.02
5	16¼	18.95	25	30.09	18¾	21.92
6	19½	22.33	30	35.38	22½	25.82
7	22¾	25.72	35	40.68	26¼	29.72
8	26	29.11	40	45.97	30	33.62
9	29¼	32.50	45	51.26	33¾	37.52
10	32½	35.88	50	56.50	37½	41.42

Catalog Height	Heating Surface in Sq. Ft. Three Tube	Five Tube	Seven Tube	"A"	"C"	Number of Cross Bars
38"	3.25	5.00	7.00	37 3/16"	30 5/64"	2
32"	2.75	4.50		31 13/64"	25 17/32"	2
26"	2.25	3.50	5.00	25 5/64"	19 15/32"	1
22"	2.00	3.00	4.25	21 7/8"	15 37/64"	0
20"		2.75	3.75	20	13 43/64"	0
18"		2.50	3.50	18 15/32"	12 25/64"	0
16"			3.25	16 13/32"	10 3/32"	0
14"			2.75	14 5/16"	8 1/64"	0

Catalog will be mailed on request showing tables of capacities and ratings, all heights and sizes of radiators, 1 to 30 sections.

RICHMOND TUBE RADIATORS

☞**We direct attention to the fact that while our base prices are in line with others, we offer vastly more for the same price. For Richmond Tube Radiators,** you pay for the number of square feet in Column A and you receive the number of square feet in Column B. For example:

For a 2-section, 38-inch, 5-tube Radiator you pay for 10 feet, you receive 14.22 feet
For a 10-section, 38-inch, 5-tube Radiator you pay for 50 feet, you receive 56.50 feet

In Column A are catalog ratings, given for comparison with ratings of manufacturers who do not publish performance tables.

In Column B are given our Guaranteed ratings, equivalent surface at 240 B.t.u. square feet, at 1 pound steam pressure, radiator standing in still air 70 deg. at breathing point (5 feet above floor).

PROX

ON THE BANKS OF THE WABASH — SINCE 1891

FRANK PROX COMPANY

TERRE HAUTE - INDIANA.

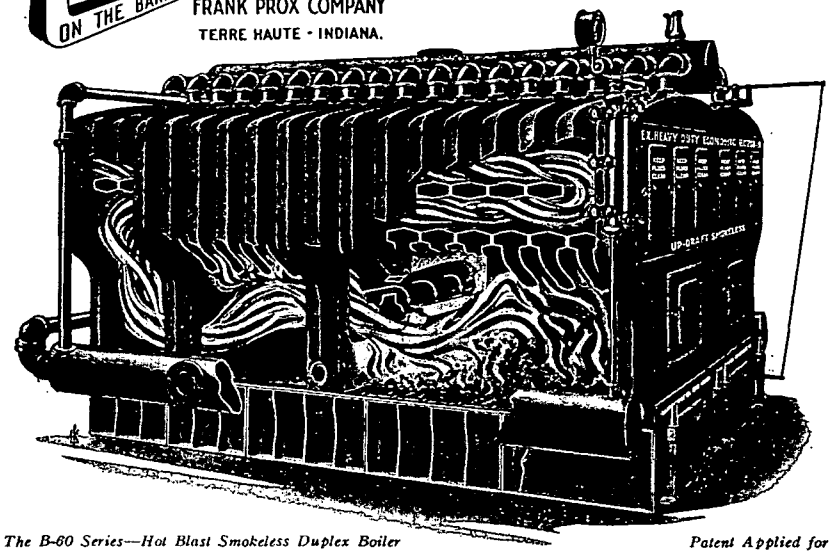
HOT BLAST SMOKELESS

Continuous Service Type Boilers

Made in

SIX SERIES

Steam Capacities, 1200 to 25,000 sq. ft.



The B-60 Series—Hot Blast Smokeless Duplex Boiler *Patent Applied for*

6 POINTS Paramount in Choosing Boilers

1—Continuous Service—Any heating plant will break if carelessly operated. Broken sections in Prox Boilers can be plugged off and heat maintained, avoiding dismissal of school or closing of building.

2—Fuel Economy—Short wide firebox design, full three-layer fire travel, **very low stack temperature, large self-cleaning flues, conservative ratings, ideal design for perfect combustion with soft coals.**

3—Long Service—Safety—Prox Cast Sectional Boilers represent maximum permanence.

4—Quick Dry-Steaming—Low water-line, small waterways, quick circulation, dry steam assured by steam separating header over Prox Boilers.

5—Repair Economy—Remove any sections like tilting book from bookcase. Other boilers must be torn down and expensive covering destroyed.

6—Installation Economy—Take flow direct from large steam separating header, saving extra cost of additional header construction necessary to get dry steam with other boilers.

PROX BOILERS—World's best for large installations in Schools, Theatres, Apartments, Churches, Hospitals, Hotels, etc.

WRITE FOR LATEST CATALOG

Smith Twin Tubular Boiler Co.

38-42 East Allen Street

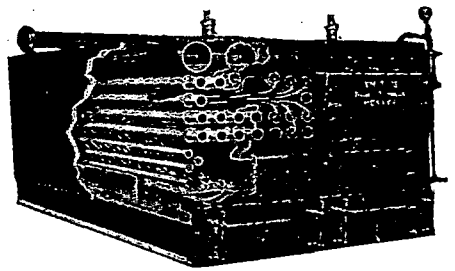
Philadelphia, Pa.

STEEL HEATING BOILERS

for

Schools — Apartments — Office Buildings — Factories

Low water line.
Enormous prime heating.
Surfaces directly over fire.
Requires less floor space.
All steel construction.
Positive gas travel.
Large combustion chamber.
Low stack temperatures.
Large liberating area and a free and rapid water circulation.
High efficiency with all fuels.



A—SERIES

Boiler Number	Rating Sq. Ft. Radiation	Grate Surface Sq. Ft.	Steam Outlets	Return Outlets	Overall Length Ins.	Overall Width Ins.	Water Line Ins.	Shell Length Ins.	Shell Width Ins.	Height Top of Outlet
A-48	2000	7.5	1-6"	1-4"	64"	42"	59"	48"	36⅝"	70"
A-54	2500	8.5	1-6"	1-4"	70"	42"	59"	54"	36⅝"	70"
A-60	3000	10.0	1-6"	1-4"	76"	42"	59"	60"	36⅝"	70"
A-66	3500	11.0	1-6"	1-4"	82"	42"	59"	66"	36⅝"	70"
A-72	4000	12.5	1-6"	1-4"	88"	42"	59"	72"	36⅝"	70"
A-78	4500	13.5	1-6"	1-4"	94"	42"	60"	78"	36⅝"	70"
A-84	5000	15.0	1-6"	1-4"	100"	42"	60"	84"	36⅝"	70"
A-90	5500	15.0	1-6"	1-4"	106"	42"	60"	90"	36⅝"	70"
A-96	6000	15.0	1-6"	1-4"	112"	42"	60"	96"	36⅝"	70"
B—SERIES										
B-72	6500	16.66	2-6"	1-4"	92"	52"	67"	72"	46⅝"	77"
B-78	7000	18.33	2-6"	1-4"	98"	52"	67"	78"	46⅝"	77"
B-84	7500	18.33	2-6"	1-4"	104"	52"	67"	84"	46⅝"	77"
B-90	8000	20.00	2-6"	1-4"	110"	52"	67½"	90"	46⅝"	77"
B-96	8500	20.00	2-6"	1-4"	116"	52"	67½"	96"	46⅝"	77"
B-102	9000	21.66	2-6"	1-4"	122"	52"	67½"	102"	46⅝"	77"
B-108	9500	21.66	2-6"	1-4"	128"	52"	68"	108"	46⅝"	77"
B-114	10000	23.33	2-6"	1-4"	134"	52"	68"	114"	46⅝"	77"
B-120	10500	23.33	2-6"	1-4"	140"	52"	68"	120"	46⅝"	77"
C—SERIES										
C-78	11000	25.00	2-8"	1-6"	98"	72"	67"	78"	66⅝"	77"
C-84	11750	27.50	2-8"	1-6"	104"	72"	67"	84"	66⅝"	77"
C-90	12500	30.00	2-8"	1-6"	110"	72"	67"	90"	66⅝"	77"
C-96	13250	32.50	2-8"	1-6"	116"	72"	67½"	96"	66⅝"	77"
C-102	14000	32.50	2-8"	1-6"	122"	72"	67½"	102"	66⅝"	77"
C-108	14750	32.50	2-8"	1-6"	128"	72"	67½"	108"	66⅝"	77"
C-114	15500	35.00	2-8"	1-6"	134"	72"	68"	114"	66⅝"	77"
C-120	16250	35.00	2-8"	1-6"	140"	72"	68"	120"	66⅝"	77"
C-126	17000	35.00	2-8"	1-6"	126"	72"	68"	126"	66⅝"	77"
D—SERIES										
D-96	18000	36.00	2-8"	1-6"	116"	82"	81"	96"	76⅝"	94"
D-102	19000	36.00	2-8"	1-6"	122"	82"	81"	102"	76⅝"	94"
D-108	20000	36.00	2-8"	1-6"	128"	82"	81"	108"	76⅝"	94"
D-114	21000	39.00	2-8"	1-6"	134"	82"	81½"	114"	76⅝"	94"
D-120	22000	39.00	2-8"	1-6"	140"	82"	81½"	120"	76⅝"	94"
D-126	23000	39.00	2-8"	1-6"	146"	82"	81½"	126"	76⅝"	94"
D-132	24000	42.00	2-8"	1-6"	152"	82"	82"	132"	76⅝"	94"
D-138	25000	42.00	2-8"	1-6"	158"	82"	82"	138"	76⅝"	94"
D-144	26000	42.00	2-8"	1-6"	164"	82"	82"	144"	76⅝"	94"

Special water line—height—width—lengths of boilers to meet special conditions. Removable jackets of heavy steel with high temperature insulation. *A.S.M.E.* Std. 15 lbs. Working Pressure.

The H. B. Smith Company

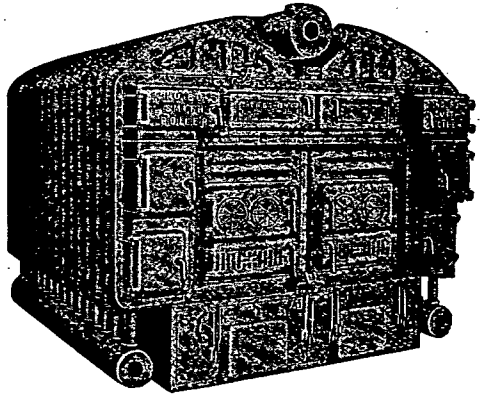
Works: Westfield, Mass.

WESTFIELD, MASS. 57 Main Street

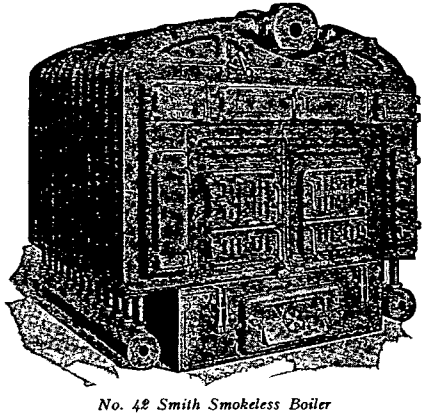
NEW YORK, 10 East 41st Street BOSTON, 640 Main Street, Cambridge

CLEVELAND, 1108 Webster Avenue, S.E. PHILADELPHIA, 49th St. and Grays Ave.

Pioneer Makers of Cast Iron Boilers and Radiators for Steam and Water Heating



No. 60 Smith Smokeless Boiler



No. 42 Smith Smokeless Boiler

SMITH SMOKELESS BOILERS

Nos. 27, 36, 42, 60

For Anthracite Coal, Oil, Gas, Coke and all Bituminous Coals.
*When Bituminous Coal contains over 22½% volatile Oxygen Torch should be installed.

No. of Sections in Boiler	Nominal Size of Fire Pot, Inches		Total Length of Boiler Inches	Length at Foundation, Inches	Steam Rating, Feet	Water Rating, Feet
	Width	Length				
No. 27*						
10	27	36	77	62	2,700	4,450
11	27	42	83	68	3,000	4,950
12	27	48	89	74	3,300	5,450
13	27	54	95	80	3,600	5,950
14	27	60	101	86	3,900	6,425
15	27	66	107	92	4,200	6,925
No. 36*						
11	36	42	87	68	4,300	7,100
12	36	48	93	74	4,800	7,925
13	36	54	99	80	5,300	8,750
14	36	60	105	86	5,800	9,575
15	36	66	111	92	6,300	10,400
No. 60*						
12	60	42	110	73	10,800	17,800
13	60	48	116	79	12,000	19,800
14	60	54	122	85	13,200	21,800
15	60	60	128	91	14,400	23,750
16	60	66	134	97	15,600	25,750
17	60	66	140	103	16,800	27,700
18	60	72	146	109	18,000	29,700
19	60	78	152	115	19,200	31,700
20	60	78	158	121	20,400	33,650

Additional Data Applying to Smokeless Boilers

Boiler No.	27	36	42	60
Width at foundation	35″	48¼″	50″	72″
Width of boiler, steam	56″	72″	68⅞″	98″
Width of boiler, water	59″	76″	68⅞″	98″
Height of boiler	80″	83″	76¾″	87″
Height of water line	57″	59″	60″	69″
Oval smoke pipe equivalent to	13½″ round	15½″ round	...	29½″ round

No. 60 Supply Drum Tappings*

Outside diameter.....12 in.
Tapped for 2-in. lock-nut nipples. Front end tapped 2 in. Rear end tapped one 4 in. and one 2 in.

Tappings on Top

Number of Sections	Size of Tappings 4″	5″	6″	8″
	Number of Tappings			
8	2	.....	2	.....
9	2	.....	2	.....
10	.....	2	.....	2
11	.....	2	.....	2
12	.....	2	.....	2
13	.....	2	.....	2
14	.....	2	.....	3
15	.....	2	.....	3
16	.....	2	.....	3
17	.....	2	.....	3
18	.....	2	.....	3
19	.....	2	.....	3
20	.....	2	.....	3

No. of Sections in Boiler	Nominal Size of Fire Pot, Inches		Total Length of Boiler Inches	Length at Foundation, Inches	Steam Rating, Feet	Water Rating, Feet
	Width	Length				
No. 27						
5	27	24	47	32	1,200	1,975
6	27	30	53	38	1,500	2,475
7	27	36	59	44	1,800	2,975
8	27	42	65	50	2,100	3,475
9	27	48	71	56	2,400	3,950
10	27	54	77	62	2,700	4,450
11	27	60	83	68	3,000	4,950
12	27	60	89	74	3,300	5,450
12	27	66	89	74	3,300	5,450
13	27	66	95	80	3,600	5,950
13	27	72	95	80	3,600	5,950
14	27	66	101	86	3,900	6,425
14	27	78	101	86	3,900	6,425
No. 36						
7	36	36	63	44	2,300	3,800
8	36	42	69	50	2,800	4,625
9	36	48	75	56	3,300	5,450
10	36	54	81	62	3,800	6,275
11	36	60	87	68	4,300	7,100
12	36	60	93	74	4,800	7,925
12	36	66	93	74	4,800	7,925
13	36	66	99	80	5,300	8,750
13	36	72	99	80	5,300	8,750
14	36	66	105	86	5,800	9,575
14	36	78	105	86	5,800	9,575
15	36	72	111	92	6,300	10,400
15	36	84	111	92	6,300	10,400
No. 60						
8	60	36	86	49	6,000	9,900
9	60	42	92	55	7,200	11,900
10	60	48	98	61	8,400	13,850
11	60	54	104	67	9,600	15,850
12	60	60	110	73	10,800	17,800
13	60	66	116	79	12,000	19,800
14	60	72	122	85	13,200	21,800
15	60	78	128	91	14,400	23,750
16	60	84	134	97	15,600	25,750
17	60	78	140	103	16,800	27,700
18	60	84	146	109	18,000	29,700
19	60	84	152	115	19,200	31,700
20	60	84	158	121	20,400	33,650

NOTE—Additional data pertaining to No. 42 boiler, furnished on application.

No. 60 Return Drums*

Steam Boilers

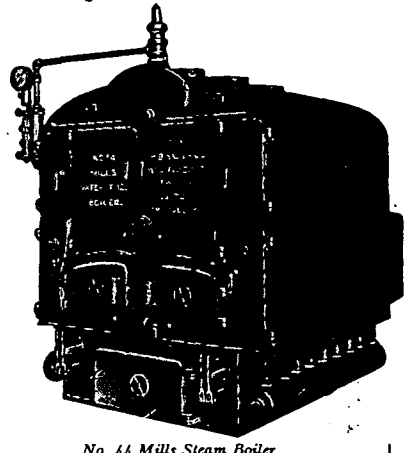
Outside diameter.....8 in.
Tapped for 2-in. lock-nut nipples.
Front ends tapped.....2½ in.
Rear ends tapped.....5 in.
Side Drip tapped.....2 in.

Fire Tools and Steam Trimmings Furnished

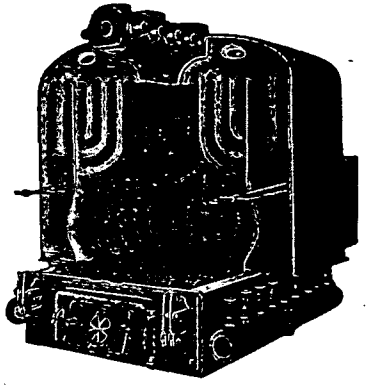
*When boiler is to be used for water warming, specify on order the size of supply and return pipe tappings. Tappings other than those listed are special. Order must specify size.

Mills Water Tube Steam and Water Boilers

Sectional cast iron boilers which are moderate in first cost, low maintenance and extremely economical in fuel. Sectional view shows large combustion chamber and vertical waterways of small area. The latter absorb the heat quickly, circulate the water rapidly and make dry steam. May be fired with anthracite coal, wood, coke, oil or fuel gas.



No. 44 Mills Steam Boiler

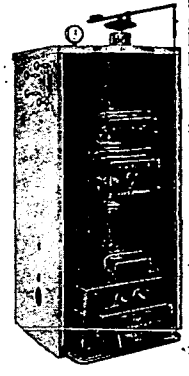


No. 44 Mills Boiler—Interior

Size of Boiler	Nominal Width Fire Pot Inches	Commercial Rating—Cap. in Sq. Ft.	
		Steam	Water
No. 24	24	700 to 2025	1175 to 3350
No. 34	34	2000 to 5200	3300 to 8575
No. 44	44	3600 to 9000	5950 to 14,850

H-B Steam and Water Boilers

H-B Boilers have three waterways between sections. They are the only boilers in which ascending and descending currents of water are circulated through separate connections, giving a steady water line and rapid circulation without back pressure.



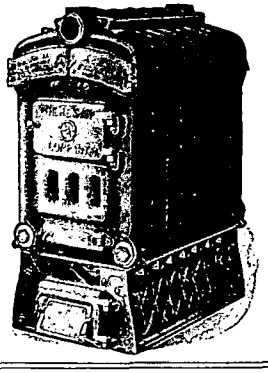
Commercial Ratings

Diam. of Fire Pot Inches	Steam Rating Feet	Water Rating Feet
15 to 27	250 to 1000	425 to 1650

17 Hy-Test Boiler

For Hot Water Supply
A. S. M. E. Standard

Maximum allowable working pressure, 120 lb. Open Tank; 80 lb. Closed Tank.



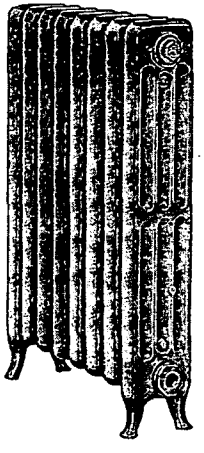
Max. Allowable Working Pressure

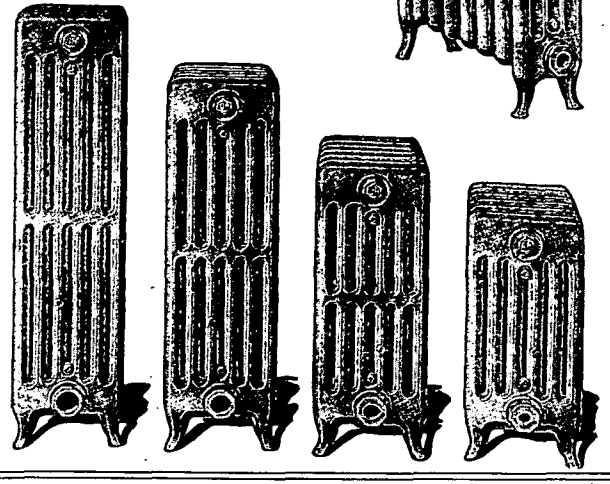
Steam	Water (Open Tank)	Water (Closed Tank)
15 lb.	30 lb.	15 lb.
15 lb.	30 lb.	15 lb.
15 lb.	30 lb.	15 lb.
15 lb.	60 lb.	30 lb.

Smith "144" Full Surface Radiators

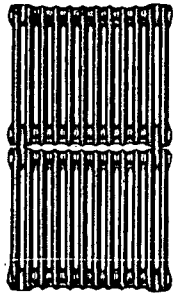
Efficiency plus New Beauty characterize this product. "144" is an attractive design to harmonize with modern ideas of interior decoration. The H. B. Smith "144" is a Full Surface Radiator. Every foot of rated surface contains 144 sq. in. of radiator surface.

Style	Height In.	Sq. Ft. per Section
Three Tube Steam or Water	37	3
	32	2½
	25	2
	21	1½
Four Tube Steam or Water	37	4
	32	3½
	25	2½
	21	2
Six Tube Steam or Water	37	6
	32	5
	25	3¾
	21	3
	14	2





Princess Wall Radiators



Suited for all places where direct radiators or pipe coils cannot be used. Especially desirable in locations where floor space is valuable and where wall, column or ceiling space is more available. They possess extreme flexibility of size and arrangement. Made in two heights, 15 and 22 in. Can be furnished with heating surfaces from 5 sq. ft. up, in multiples of 2½ sq. ft. Corresponding lengths in 22 in. radiators are from 9 in. up, in multiples of 4 in. (1 in. allowed in over all length for plugs and bushings). In the 15 in. radiator, corresponding lengths are from 13 in. up, in multiples of 6 in. By combinations of the two heights, these radiators can be arranged in tiers, either for horizontal runs or for column work. Hung horizontally, they make excellent ceiling radiators.

Spencer Heater Company

Division of Lycoming Manufacturing Company

Makers of Spencer Heaters

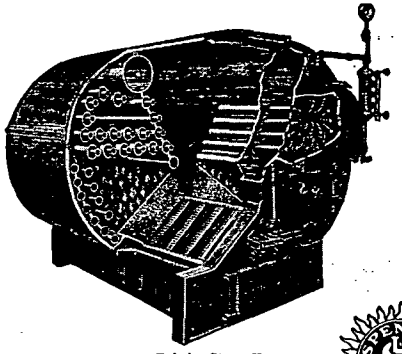
Williamsport, Pa.

NEW YORK, N.Y. PHILADELPHIA, PA. ALBANY, N.Y. SCRANTON, PA. BUFFALO, N.Y.
BOSTON, MASS. BALTIMORE, MD. SYRACUSE, N.Y. HARRISBURG, PA. ROCHESTER, N.Y.

PRODUCTS: Spencer Magazine Feed Heaters

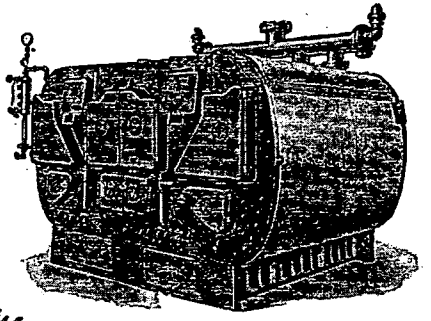
The Spencer Heater is the original Magazine Feed Heater with sloping grates. The Water-jacketed Magazine holds enough fuel for 12 to 24 hours, without attention. As fuel feeds automatically, as fast or as slow as the fire requires, the Magazine supply lasts longer in milder weather.

Spencer Heaters are made in sizes to suit any building, large or small, either in steel tubular types or cast iron sectional types. Commercial ratings have been discontinued. Capacities are guaranteed when installed under normal conditions, according to the table below and on the following page, when used with any low pressure steam, vapor, or hot water system.



50 Series, Spencer Tubular Steam Heater

For large building work—an efficient Magazine Heater of combination water-tube and return-tube construction.



100 Series, Spencer Tubular Steam Heater

The largest type of Spencer Heater, a four grate heater for use in multiple story buildings.

Sizes and Guaranteed Capacities of Spencer Steel Tubular Heaters

	Heater No.	*Direct Cast Iron Column Radiation Loads Sq. Ft.	Grate Area	Draft Required	Outlets No. and Size	Returns No. and Size	Chimney Flue	Diam. of Smoke Pipe	Overall Dimensions Length	Width	Height
15-21 Series	15	1600	12.00	0.23	2-4"	2-2"	18"x18"x50'	16"	72½	60	63¼
	17	1950	13.00	0.24	2-4"	2-2"	18"x18"x55'	16"	78½	60	63¼
	19	2300	15.00	0.25	2-4"	2-2"	18"x18"x60'	16"	84½	60	63¼
	20	2650	16.50	0.26	2-4"	2-2"	18"x18"x65'	16"	90½	60	63¼
	21	3000	18.00	0.27	2-4"	2-2"	18"x18"x65'	16"	96½	60	63¼
50 Series	3-45	3600	18.05	0.24	2-5"	2-2½"	18"x18"x50'	18"	99½	81¼	71¾
	3-50	4100	20.24	0.25	2-5"	2-2½"	18"x18"x55'	18"	105¾	81¼	71¾
	3-55	4600	22.56	0.26	2-5"	2-2½"	18"x18"x60'	18"	112	81¼	71¾
	3-60	5100	24.83	0.27	2-5"	2-2½"	20" Diam. x 65'	18"	118¼	81¼	71¾
	3-70	5600	27.00	0.28	2-5"	2-2½"	20" Diam. x 70'	18"	124½	81¼	71¾
100 Series	3-80	6500	30.35	0.27	1-8"	2-2½"	24" Diam. x 65'	22"	98	116⅛	100
	3-90	7600	34.70	0.28	1-8"	2-2½"	24" Diam. x 65'	22"	104½	116⅛	100
	3-105	8700	39.05	0.29	1-8"	2-2½"	30" Diam. x 65'	22"	110½	116⅛	100
	3-120	9800	43.40	0.30	1-8"	2-2½"	30" Diam. x 70'	22"	116¾	116⅛	100
	3-140	10900	47.75	0.32	1-8"	2-2½"	36" Diam. x 70'	22"	123	116⅛	100
	3-160	12000	52.10	0.34	1-8"	2-2½"	36" Diam. x 70'	22"	129¼	116⅛	100

*This includes ample provision for heat loss in covered mains, risers and returns, and for peak loads.
Heaters Nos. 3-45 to 3-160 are furnished with steel jackets and 1½ in. Rockwool Asbestos Coverings, also pipe header.
Heaters Nos. 15-21 are furnished with steel jackets only.
Chimney flue sizes are based on a maximum flue temperature at boiler smoke outlet of 500° Fahr.

Special Features for Different Types of Buildings

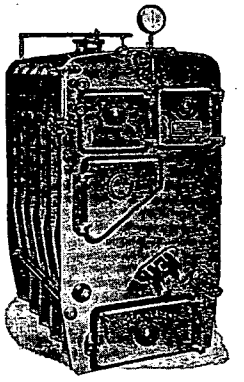
Spencer Heaters are especially efficient in industrial buildings, greenhouses and garages where uniform heat is desirable; and in churches, theatres, schools and buildings where they give constant, even and uniform heat, without the attention of a night fireman. For the home, the Spencer is especially convenient, as it needs attention only once or twice in twenty-four hours.

Spencer Economy for Building Owners

Though Spencer Heaters are designed to burn any non-coking graded fuel, their greatest saving is made with small sized, low cost fuels. They save as much as half the owner's annual fuel bill by using No. 1 Buckwheat anthracite, and proportionately by using by-product Pea or Buckwheat coke. Where anthracite and coke are not available, they are equally efficient when fired with smaller sizes of semi-bituminous, such as Pocahontas, or any non-coking graded fuel.

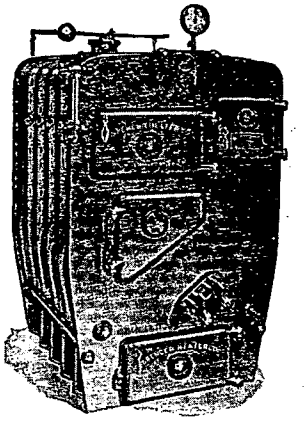
Automatic Magazine Feed Gives Steady Heat

Fuel is fed automatically by gravity—no blowers or mechanical apparatus are needed. They are easy to install—the new Spencer Heaters are as easy to erect as any other sectional heater on the market—and there is nothing to get out of order. Write for complete descriptions and illustrations of all Spencer Heaters.



L-1 Type, Spencer Sectional Heater

A Magazine Heater for steam, vapor or hot water systems, in six to twelve room dwellings or industrial buildings of moderate size.



L-2 Type, Spencer Sectional Heater

A Magazine Heater for large dwellings, industrial buildings and institutional buildings.

Sizes and Guaranteed Capacities of Spencer Cast Iron Sectional Heaters

	Heater No.	*Direct Cast Iron Column Radiation Loads, Sq. Ft. Steam	Water	Grate Area	Draft Required	Outlets, No. and Size Steam	Water	Returns No. and Size Steam and Water	Chimney Flue	Diam. of Smoke Pipe	Overall Dimensions Length	Width	Height
L-1 Type	L-104	270	445	1.88	0.12	1-4"	1-4"	2-4"	8"x8"x35'	10"	32	32	57
	L-105	390	645	2.60	0.12	1-4"	1-4"	2-4"	8"x8"x35'	10"	39	32	57
	L-106	510	845	3.33	0.12	2-4"	2-4"	2-4"	8"x8"x35'	10"	46	32	57
	L-107	630	1045	4.07	0.12	2-4"	2-4"	2-4"	8"x12"x35'	10"	53	32	57
	L-108	750	1245	4.80	0.12	2-4"	2-4"	2-4"	8"x12"x35'	10"	60	32	57
L-2 Type	L-205	550	910	3.63	0.12	1-4"	1-4"	2-4"	8"x12"x35'	10"	39	40	60
	L-206	725	1200	4.66	0.12	2-4"	2-4"	2-4"	8"x12"x35'	10"	46	40	60
	L-207	900	1490	5.68	0.12	2-4"	2-4"	2-4"	8"x12"x40'	10"	53	40	60
	L-208	1075	1780	6.70	0.12	2-4"	2-4"	2-4"	12"x12"x40'	10"	60	40	60
	L-209	1250	2070	7.73	0.12	2-4"	2-4"	2-4"	12"x12"x40'	10"	67	40	60
S-2 Type	S-2-7	1060	1700	6.77	0.18	2-4"	2-4"	2-4"	12"x12"x40'	12"	74⅞	57⅜	62¾
	S-2-8	1300	2080	7.90	0.19	2-4"	2-4"	2-4"	12"x12"x40'	12"	81⅛	57⅜	62¾
	S-2-9	1540	2460	9.03	0.20	2-4"	2-4"	2-4"	12"x12"x40'	12"	87⅜	57⅜	62¾
	S-2-10	1780	2840	10.16	0.21	2-4"	2-4"	2-4"	12"x18"x45'	12"	93⅝	57⅜	62¾
	S-2-11	2020	3220	11.29	0.21	2-4"	2-4"	2-4"	12"x18"x45'	12"	99⅞	57⅜	62¾

*This includes ample provision for heat loss in covered mains, risers and returns, and for peak loads.

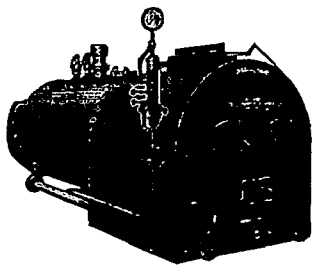
The Stanwood Corporation

ESTABLISHED 1891

Manufacturers of Stanwood Smokeless Boilers for Heating and Power Service and Horizontal Return Tubular Boilers.

Cincinnati, Ohio

Stanwood Smokeless Boilers



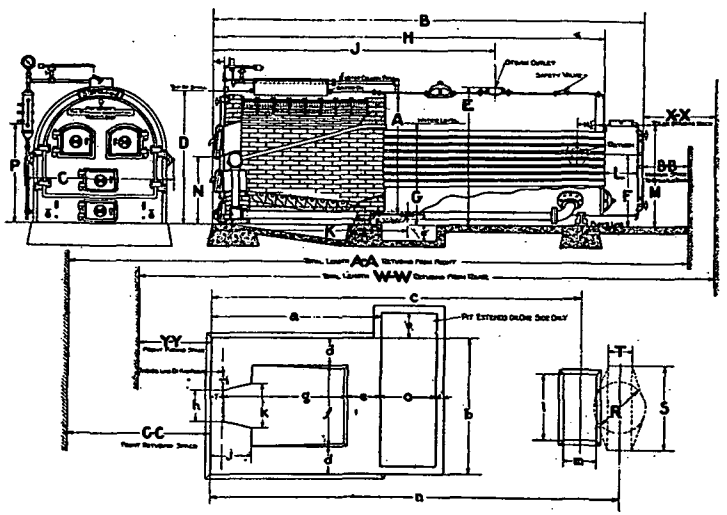
Low Water Line—An important feature of Stanwood Smokeless Boilers is the low water level from 48 to 75 in. depending upon size. This valuable characteristic for a heating boiler gives it wider application and is particularly appropriate where there is limited head room in the basement.

Shell cannot be bagged or burned nor can its circumferential seams be cracked. Nowhere are these surfaces exposed to the fire. Boiler has no firebox or mudlegs to fill up and corrode; no staybolts to rust or break off; no crownsheet to drop if water is low. There is no internal flue that can collapse.

High over-all efficiency due to high combustion and the smokeless performance of a down-draft furnace; low stack temperature, secured through rapid circulation, no air leaks and a minimum radiation loss.

Primarily intended to burn bituminous coal with down-draft furnace. Can also be operated with oil, gas, anthracite or coke.

Stanwood Smokeless Boilers are built in sizes from (3500 to 31,000 sq. ft. steam radiation) 29 to 250 hp. for working pressures of 15, 100, 125 and 150 lbs. Can be built for higher pressure if desired.



STANWOOD SMOKELESS BOILERS—STEEL-RIVETED

General Specifications and Dimensions

	Number of Boiler	†608	610	612	614	616	618	620	622	624	626	628
	Heating Capacity—Steam....Sq. Ft.	3500	5000	6000	8500	10000	12000	16000	18500	22000	26000	31000
	Heating Capacity—Water....Sq. Ft.	5600	8000	9600	13600	16000	19000	26000	30000	35000	42000	50000
	Horsepower	29	40	50	70	80	100	125	150	175	210	250
A	Diameter of Boiler Shell....In.	44	54	54	60	66	72	78	84	90	90	90
B	Length of Boiler overall....Ft.-In.	14-6	15-10	18-10	18-11	19-6	19-7	19-8	20-4	20-8	24-0	26-0
C	Width of Boiler overall, maximum. In.	66	66	66	72	78	86	91	98	104	104	104
	Heating Surface....Sq. Ft.	308	422	518	692	814	990	1260	1500	1774	2106	2540
	Upper Grate Surface....Sq. Ft.	10½	14	17½	20	22	25	27½	33	36	39	42
	Lower Grate Surface....Sq. Ft.	7½	12½	15¾	18	20	22½	25	30¼	33	36	39
	Openings—Steam Outlet...Diam. In.	5	6	6	6	8	8	8	8	8	10	10
	Return Inlet...Diam. In.	3	4	4	5	5	5	6	6	6	6	6
	Safety Valve...Diam. In.	2	2½	3	3	3½	3½	4	4½	2-3½	2-3½	2-4
	Blow-off or Drain Pipe....Diam. In.	1½	2	2	2	2	2	2	2½	2½	2½	2½
D	Height, Floor to top of Shell....In.	64	64	64	67	73¼	79	85½	91¼	97	97	97
E	" " Steam Outlet. In.	61	66	66	69	75¼	82¼	87½	93¼	99½	99½	99½
F	" " Return Inlet....In.	36¼	36¼	36¼	36¼	39½	42¼	45½	48½	51½	51½	51½
G	" " Water Level....In.	48	49¼	49¼	51	57	61	67	70¾	75	75	75
H	Front of Foundation to Back Head....Ft.-In.	13-1½	14-2½	17-2½	17-2½	17-9	17-9	17-9	18-3	18-3	21-5	22-11
J	Steam Outlet....Ft.-In.	9-4½	10-11½	12-3½	12-3½	12-10	12-10	12-10	13-4	13-4	16-4	17-4
K	Blow-off....Ft.-In.	6-5	7-11¼	8-11¼	8-11¼	9-1	9-1	9-1	9-7	9-7	10-1	10-7
L	Depth of Smoke Box....In.	15	16½	16½	17½	18¼	19½	20½	22½	26¼	27	33
M	Height, Floor to Base of Stack Saddle....In.	58½	49¾	49¾	51¾	56	61¼	67½	71¼	77	77	77
N	Height, Floor to Upper Fire Door..In.	37¼	37¼	37¼	36¾	39¼	39¼	42½	41½	47	47	47
R	Stack, Diam. and Height, minimum for 1 Boiler....In.xFt.	20x55	22x55	24x60	26x65	28x65	30x70	32x70	34x80	36x90	39x100	42x100
	Breeching Diam. for 1 Boiler....In.	22	24	26	28	30	32	34	36	38	42	44
	Stack Diam. and Height for 2 Boilers, minimum....In.xFt.	30x65	32x65	32x70	34x70	36x75	42x80	46x80	48x90	50x100	54x100	60x100
	Breeching Diam. for 2 Boilers....In.	32	34	34	38	38	46	50	52	54	58	64
T-S	Sizes of Rectangular Stack Saddle. In.	*9x34	11x36	11x36	12x42	13x46	14x52	15x58	17x64	21x60	22x70	25x70
	No. of Straight Fire Brick...Approx.	350	325	390	440	760	630	725	780	970	1000	1090
	" Split Fire Brick....Approx.	14	14	20	20	20	20	20	20	20	22	26
	" No. 1 Arch Fire Brick. Approx.	60	100	130	130	110	100	120	120	170	180	210
	" Sil-o-cel Brick....Approx.	75	50	60	75	100	150	150	250	300	325	375
	" Common Red Brick..Approx.	100	210	220	275	400	475	600	500	600	625	675
	Outside Insulated Covering...Sq. Ft.	180	200	235	255	290	315	345	376	410	500	560
	Boilers in pairs, center to center...In.	78	78	78	84	90	96	102	108	114	114	114
	Total Weight (approximate) No Stack or Brickwork....Lbs.	9000	10700	11600	13900	17500	19400	24000	25700	28500	32000	36000

Standard Foundation Dimensions and Space Required for Installing

Size	Foundation													Retubing From (See Note ‡)					
	Dimensions—Feet and Inches													Front			Rear		
	a	b	c	d	e	f	g	h	j	k	l	m	n	o	A-A	B-B	C-C	W-W	X-X	Y-Y
608	5-6	5-4	12-0	16	19	32	3-4	17	22½	24	30	12	13-10½	2-6	23- 9	25	7-2	27- 4	6-10	6-0
610	6-3	5-8	13-3	15	18	38	4-2	17	22½	24	30	12	14-11	2-6	25- 5	29	7-2	28- 8	6-10	6-0
612	7-3	5-8	16-3	15	18	38	5-2	17	22½	24	30	12	17-11	2-6	30- 4	29	9-1	35- 8	8-10	8-0
614	7-3	6-2	16-3	15	18	44	5-2	17	22½	24	30	12	17-11½	2-6	30- 4	32	8-9	35- 8	8- 9	8-0
616	7-9	6-8	16-9	18	18	44	5-8	17	22½	24	30	12	18- 6	2-6	31-11	35	9-6	37- 9	8- 9	9-6
618	7-9	7-3	16-9	18	18	51	5-8	17	22½	24	36	18	18-6½	2-6	32- 3	38	9-6	37- 8	8- 7	9-6
620	7-9	7-9	16-9	18	18	57	5-8	17	22½	24	36	18	18- 7	2-6	32- 7	41	9-6	37- 9	8- 7	9-6
622	8-3	8-3	17-3	18	18	63	6-2	40	22½	48	36	18	19- 2	2-6	34- 0	44	10-0	38- 8	8- 4	10-0
624	8-9	8-9	17-3	18	18	69	6-8	40	22½	48	48	24	19- 4	2-6	34- 7	47	10-0	39- 0	8- 4	10-0
626	9-3	8-9	20-6	18	18	69	7-2	40	22½	48	48	24	22-10	2-6	40- 5	47	12-6	46- 4	11- 4	11-0
628	9-9	8-9	22-0	18	18	69	7-8	40	22½	48	48	24	24- 7	2-6	43- 5	47	13-6	49-10	12- 4	11-6

Each of these boilers will carry its full rated load in direct cast iron radiation, or the equivalent thereof, provided sufficient radiation is installed to heat to the required temperature.

*Oval Ends used on 608 size only.

†Handhole under tubes in rear head on 608 size only. All other sizes with 11 x 15 manhole.

Trimmings furnished with 15 lbs. Boilers.

Water column with gage cocks (no column piping furnished), steam gage with siphon and cock; pop safety valves. Automatic Damper Regulator with lever, weight, chain and angle valve, wrench for header plugs. Firing tools include hoe, poker, slice bar, tube scraper and brush.

‡If space lengthwise is limited provision may be made for rear retubing by providing opening opposite rear end of boiler through which tubes may be withdrawn. Then dimension X-X may be reduced to B-B. Otherwise boiler may be retubed from front by allowing space C-C in front of boiler. Where installation limits are close or in question, consult our Engineering Department.

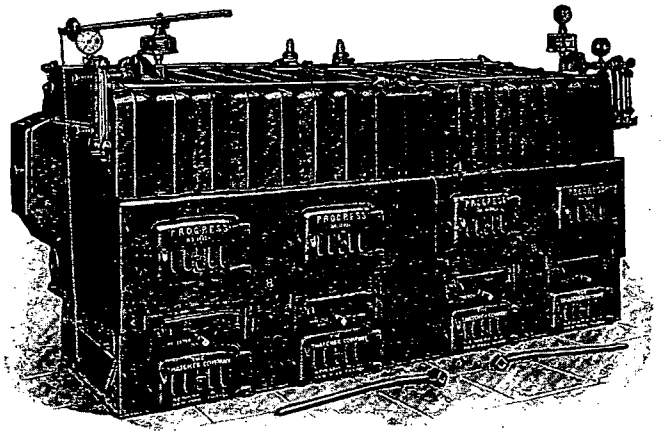
The Thatcher Company

New York
Chicago

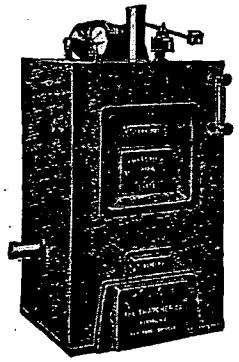
39-41 St. Francis St.
Newark, N. J.

Agencies in All Principal Cities

Boilers—Furnaces—Ranges—Radiators



A Sixteen Section Progress Boiler



Thatcher "Elite" Red Enamel Jacketed Boiler

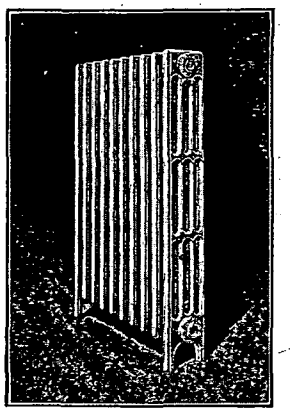
The Thatcher Progress Boiler has such an unusually low water line that it can be used in the shallowest cellars without need of a boiler pit.

In both Thatcher Round and Sectional Boilers, the "staggered fire travel" principle applies. This shunting of the flames back and forth assures complete combustion of the gases, as proven by the low stack temperatures.

The Elite Boiler is lined with 1¼ in. asbestocel and also insulated by the dead air space between the boiler and the casing, making it unusually efficient.

The Thatcher Gothic Radiators were designed not only for greater beauty, but also for increased efficiency.

Other Thatcher products include Gas Ranges, Coal Ranges, Combination Gas and Coal Ranges, Warm Air Furnaces, Ship Ranges, Garage Heaters and Tank Heaters.



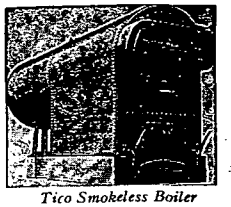
Thatcher "Gothic" Radiator

The Titusville Iron Works Company

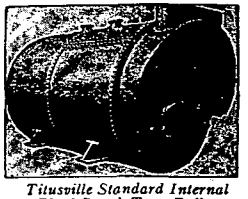
Titusville, Pennsylvania

Manufacturers of Fire Tube Steel Boilers for Power and Heating; Fronts, Grates, Castings, Smoke Stacks, Tanks and Oil Well Boilers; Steam, Gas, Oil and Gasoline Engines; Pumping Powers and Oil Well Machinery

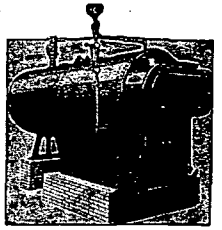
New York Office.....152 West 42nd St.
Chicago Office, 1124 Harris Trust Bldg.
Buffalo Office.....Marine Trust Bldg.
Detroit Office.....204 Owen Bldg.
Pittsburgh Office....Farmers Bank Bldg.
Washington Office.....Woodward Bldg.
Los Angeles Office.....940 Maple Ave.
St. Louis Office, 401-2 Bk of Commerce Bldg.



Tico Smokeless Boiler



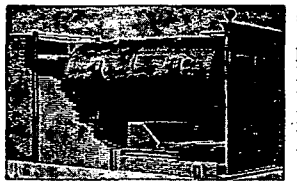
Titusville Standard Internal Fired Scotch Type Boiler



Tico Return Tubular Fire Box Boiler



Titusville Vertical Tubular Boiler



Titusville Standard H.R.T. Boiler and Setting

The Organization and Facilities

We manufacture a complete line of fire tube steam boilers to meet all general heating and power requirements. We also make a specialty of boilers built to architects' and engineers' specifications.

Our shop is one of the largest and best equipped boiler manufacturing plants in the country. It is provided with the latest improved machinery including hydraulic and pnuematic riveting machines, modern welding equipment for both gas and electric welding as well as hydraulic flanging equipment. Engineering skill, careful workmanship and the best of materials are combined to make TITUSVILLE BOILERS better made boilers for every purpose.

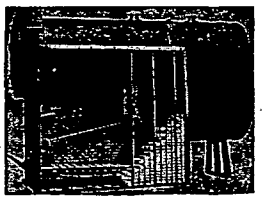
All boilers are made in strict accordance with the latest boiler code of the *American Society of Mechanical Engineers* and can be made, if desired, to conform to local requirements.

A large supply of material for all types of boilers is constantly carried and an adequate stock of completed TICOS, ACME and WELDED FIREBOX Boilers is always ready for immediate shipment.

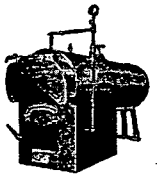
Thorough inspections and tests are constantly made during the construction and all workmanship and material is guaranteed first class in every respect.

In addition to the line of TITUSVILLE Boilers illustrated herewith we manufacture pneumatic and storage tanks of every description.

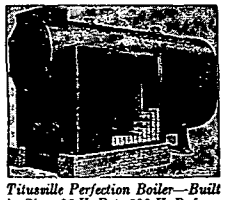
Descriptive Bulletins will be sent on request.



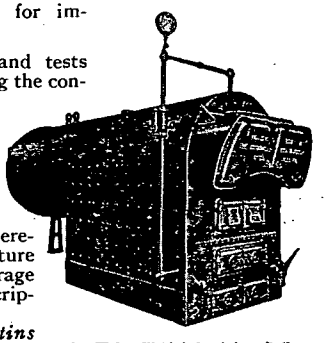
Perfection Down Draft Smokeless Boiler



Updraft Welded Type Boiler



Titusville Perfection Boiler—Built in Sizes 25 H. P. to 200 H. P. from 15 lbs. to 150 lbs Working Pressure



Series W.S.—Welded Smokeless Boiler

UNITED STATES RADIATOR CORPORATION

GENERAL OFFICES: DETROIT, MICHIGAN

Manufacturers of Capitol Boilers and Radiators

Branch and Sales Offices

*Boston, Mass.	*Brooklyn, N. Y.	*Cincinnati, Ohio	*Kansas City, Mo.
*Cambridge, Mass.	*Harrison, N. J.	Detroit, Mich.	*St. Louis, Mo.
*Portland, Me.	*Philadelphia, Pa.	*Chicago, Ill.	*Des Moines, Iowa
*Springfield, Mass.	*Baltimore, Md.	*Milwaukee, Wis.	*Omaha, Neb.
*Providence, R. I.	Buffalo, N. Y.	*Indianapolis, Ind.	*Denver, Colo.
*New Haven, Conn.	*Rochester, N. Y.	*Louisville, Ky.	*Portland, Ore.
*Troy, N. Y.	Pittsburgh, Pa.	*Birmingham, Ala.	*Seattle, Wash.
New York, N. Y.	*Cleveland, Ohio	*St. Paul, Minn.	*San Francisco, Calif.
*New Rochelle, N. Y.	*Columbus, Ohio		*Los Angeles, Calif.

*Assembling Plants located at points indicated by asterisk

Manufacturing Plants Located in Following Cities

Bristol, Pa.; Corry, Pa.; Detroit, Mich.; Dunkirk, N.Y.; Edwardsville, Ill.; Geneva, N.Y.; Waukegan, Ill.; West Newton, Pa.

CAPITOL BOILERS

In choosing the correct size of boiler for any building there is one and only one consideration; will it properly heat the required number of square feet of radiation?

The net cast iron radiating surface that each type and size of Capitol Boiler will heat adequately has been determined and is guaranteed in writing.

When the needed radiating surface is known and contributing factors checked, the selection of the proper Capitol Boiler becomes a simple matter.

GUARANTEE

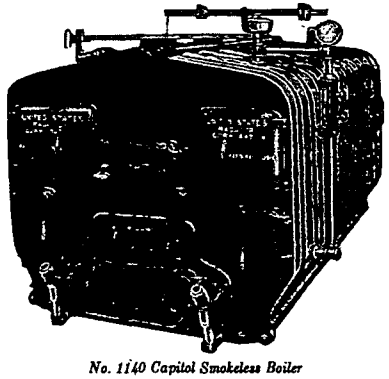
The United States Radiator Corporation will give with each Capitol Boiler sold, an absolute guarantee in writing that it will properly heat its full published amount of direct cast iron radiation provided only that the boiler is connected to a correctly installed system and that the recognized standard requirements are followed. Should any Capitol Boiler not meet these conditions, the additional capacity necessary will be supplied without charge by the United States Radiator Corporation.

Capitol Smokeless Boilers

"Smokeless" simply means complete combustion. And all of the carbon which forms smoke cannot be burned without the correct amount of air, oxygen.

The auxiliary inlets that supply air for complete combustion in Capitol Smokeless Boilers are not dependent upon the skill, guesswork or memory of the fireman.

Their size for each boiler rating is definitely determined in the Capitol Testing Laboratory and permanently fixed at the factory. They need no adjusting. The intensity of the fire itself governs the amount of air drawn in. To further assure accuracy, every Capitol auxiliary inlet is always an integral part of a single boiler section and is never placed between two sections where faulty assembly will cause a variance.



No. 1140 Capitol Smokeless Boiler

Capitol Smokeless Boilers

RADIATOR LOADS AND DIMENSIONS

Boiler No.	*Direct Cast Iron Radiator Loads, Sq. Ft. Steam	Water	Height of Water Line, Inches	Grate Area Sq. Ft.	Coal Capacity, Cu. Ft.	Outlets and Inlets	Min. Chimney Sizes Height Feet	Dimensions Inches
520	600	990	46½	3.48	4.32	2-3"	40	12 x 12
620	800	1320	46½	4.37	5.42	2-3"	40	12 x 12
720	1000	1650	46½	5.26	6.52	3-3"	40	12 x 16
820	1200	1980	46½	6.15	7.62	3-3"	45	12 x 16

*See Guarantee.

Height including trimmings 66½ in.; width 45 in.

627	1000	1650	45½	5.32	7.93	2-4"	40	12 x 12
727	1225	2020	45½	6.55	9.75	2-4"	40	12 x 12
827	1450	2390	45½	7.78	11.37	3-4"	45	12 x 12
927	1675	2760	45½	9.01	13.09	3-4"	45	12 x 16
1027	1900	3135	45½	10.24	14.81	3-4"	45	12 x 16
1127	2125	3505	45½	11.47	16.53	3-4"	50	12 x 16
1227	2350	3875	45½	12.70	18.25	4-4"	50	12 x 16

Height including trimmings 68½ in.; width 50¾ in.

740	2500	4125	49	8.15	10.40	2-5"	50	18 x 18
840	3000	4950	49	10.31	13.30	2-5"	55	18 x 20
940	3500	5775	49	10.31	13.30	2-5"	60	20 x 20
1040	4050	6680	49	12.47	16.30	3-5"	65	20 x 24
1140	4500	7425	49	14.63	19.25	3-5"	70	24 x 24
1240	4900	8085	49	14.63	19.25	3-5"	70	24 x 28
1340	5400	8910	49	16.79	22.20	3-5"	75	24 x 28

Height including trimmings 71 in.; width 75 in.

750	4700	7755	66	18.29	29.67	3-5"	55	24 x 24
850	5350	8825	66	21.33	34.68	4-5"	60	24 x 24
950	5850	9655	66	21.33	34.68	4-5"	65	24 x 28
1050	6500	10725	66	24.37	39.69	5-5"	70	24 x 28
1150	7000	11550	66	24.37	39.69	6-5"	80	28 x 28
1250	7650	12620	66	27.41	44.71	6-5"	90	28 x 32
1350	8150	13450	66	27.41	44.71	6-5"	95	32 x 32

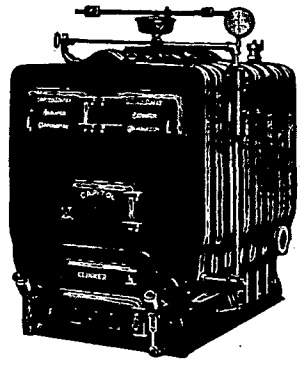
Height including trimmings 92 in.; width 82 in.

Capitol Boilers—Square Type

In this group of Capitol Boilers is presented a wide range of sizes from the smallest, the 180 series designed to provide full boiler efficiency in the smallest space, to the largest, the WN 270 series designed and built for heavy duty work.

Many years of service in buildings of every nature throughout the United States have established a reputation for these boilers which is unsurpassed. Contributing factors to the remarkable ease of operation and efficiency of performance are the spacious ash-pit; the correct proportioning of draft openings; the long fire travel and the scientific shaping of the direct and indirect heating surfaces; the durable easy shaking and dumping grates; the big doors; the easily cleaned flues.

The exceptionally low water line of certain sizes permits foundations less deep than usual—an especially important economy where water, sand or rock makes excavating difficult and expensive.



RADIATOR LOADS AND DIMENSIONS

Boiler No.	*Direct Cast Iron Radiator Loads, Sq. Ft. Steam	Water	Height of Water Line, Inches	Grate Area Sq. Ft.	Coal Capacity, Cu. Ft.	Outlets and Inlets	Min. Chimney Sizes Height Feet	Dimensions Inches
184	200	330	40½	1.88	2.33	2-3"	35	8 x 8
185	300	495	40½	2.63	3.17	2-3"	35	8 x 12
186	400	660	40½	3.38	4.01	2-3"	35	8 x 12
187	500	825	40½	4.13	4.84	2-3"	40	8 x 12

*See Guarantee.

Height including trimmings 61½ in.; width 36¾ in.

204	350	580	46½	2.59	4.36	2-3"	35	8 x 12
205	500	825	46½	3.48	5.85	2-3"	35	8 x 12
206	625	1030	46½	4.37	7.34	2-3"	35	12 x 12
207	750	1240	46½	5.26	8.83	3-3"	40	12 x 12

Height including trimmings 66½ in.; width 45 in.

255	750	1240	49	5.66	8.37	2-4"	40	8 x 12
256	925	1525	49	7.08	10.45	2-4"	40	8 x 12
257	1125	1855	49	8.50	12.53	3-4"	40	12 x 12
258	1300	2145	49	9.92	14.62	3-4"	45	12 x 12

Height including trimmings 70½ in.; width 51 in.

G276	800	1320	45½	5.32	7.93	2-4"	40	12 x 12
G277	980	1620	45½	6.55	9.65	2-4"	40	12 x 12
G278	1160	1920	45½	7.78	11.37	3-4"	45	12 x 12
G279	1350	2220	45½	9.01	13.09	3-4"	45	12 x 12

Height including trimmings 68½ in.; width 50¾ in.

235	1200	1980	55	7.28	11.01	2-4"	40	12 x 16
236	1500	2475	55	9.11	13.75	2-4"	45	12 x 16
237	1800	2970	55	10.94	16.49	3-4"	45	16 x 16
238	2100	3465	55	12.77	19.22	3-4"	50	16 x 16
239	2400	3960	55	14.61	21.96	3-4"	50	16 x 16
240	2500	4125	55	16.44	24.70	4-4"	60	16 x 16

Height including trimmings 78 in.; width 58¾ in.

4106	2000	3300	49	10.31	13.30	‡2-5"	45	18 x 18
4107	2500	4125	49	12.47	16.30	2-5"	50	18 x 18
4108	3000	4950	49	14.63	19.25	2-5"	55	18 x 20
4109	3500	5775	49	16.79	22.25	3-5"	60	20 x 20
4110	4000	6600	49	18.95	25.20	3-5"	65	20 x 24
4111	4500	7425	49	21.11	28.20	3-5"	70	24 x 24

‡Outlets. Two 6 in. inlets are located in the rear of the back section of 4100 series boilers.

Height including trimmings 71 in.; width 75 in.

WN276	3700	6105	66	15.25	24.66	3-5"	50	20 x 24
WN277	4300	7095	66	18.29	29.67	3-5"	55	24 x 24
WN278	4900	8085	66	21.33	34.68	3-5"	60	24 x 24
WN279	5500	9075	66	24.37	39.69	4-5"	60	24 x 24
WN280	6100	10065	66	27.41	44.71	4-5"	65	24 x 28
WN281	6700	11055	66	30.45	45.96	4-5"	70	28 x 28
WN282	7300	12045	66	30.45	47.21	4-5"	70	28 x 28
WN283	7900	13035	66	30.45	48.46	5-5"	75	28 x 32
WN284	8500	14025	66	30.45	49.72	5-5"	80	32 x 32

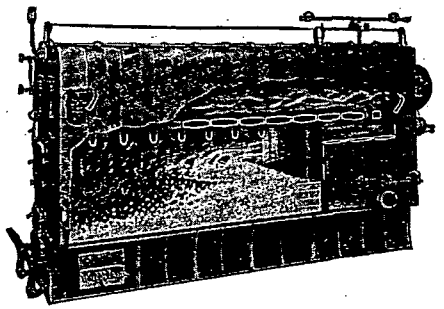
Height including trimmings 92 in.; width 82 in.

Weil-McLain

SCIENTIFIC COMBUSTION

BOILERS

WEIL-McLAIN COMPANY — Manufacturing Division: Michigan City, Ind., Erie, Pa. — General Offices: Chicago, Ill.



Smokeless Type

Weil-McLain Long Firing Period Smokeless Boilers are now making smokelessness popular with everyone—for three primary reasons:—

First: They require considerably less firing attention than smokeless boilers in general.

Second: They are simple to fire.

Third: They are not limited to free burning types of soft coal for effective operation.

STEAM		WATER		Area Complete Firebox at Grate Sq. Ft.	Net Area of Fuel Grates Sq. Ft.	Water Line Height Inches	Outlets and Inlets Number and Size Each Inches	Recommended Chimney Sizes
Size	Rating Sq. Ft.	Size	Rating Sq. Ft.					
722-S	1810	722-W	2990	7.03	4.88	46	2-3½	12x12x40
822-S	2105	822-W	3475	8.11	5.96	46	3-3½	12x12x45
922-S	2400	922-W	3960	9.19	5.96	46	3-3½	12x12x50
1022-S	2695	1022-W	4445	10.26	7.03	46	4-3½	12x12x55
752-S	2460	752-W	4060	8.10	5.70	51	2-3½	12x12x45
852-S	2995	852-W	4940	9.30	6.90	51	3-3½	12x16x45
952-S	3530	952-W	5825	10.50	6.90	51	3-3½	16x16x45
1052-S	4065	1052-W	6710	11.70	8.10	51	4-3½	16x16x50
782-S	4210	782-W	6950	11.47	7.97	55	2-4	16x16x50
882-S	5060	882-W	8350	13.22	9.72	55	3-4	16x16x55
982-S	5800	982-W	9570	14.97	11.47	55	3-4	16x20x55
1082-S	6550	1082-W	10,810	16.72	13.22	55	4-4	16x20x60
704-S	6800	704-W	11,200	15.00	11.40	57	2-5	20x20x60
804-S	7850	804-W	12,900	17.50	13.90	57	3-5	20x20x65
904-S	8900	904-W	14,600	20.00	16.40	57	3-5	20x20x65
1004-S	9950	1004-W	16,300	22.50	18.90	57	4-5	20x24x65
1104-S	11,000	1104-W	18,000	25.00	18.90	57	4-5	20x24x65
1204-S	12,000	1204-W	19,650	27.50	21.40	57	5-5	20x24x70
1304-S	13,000	1304-W	21,300	30.00	21.40	57	5-5	24x24x70
844-S	8480	844-W	13,990	20.85	15.35	58	3-5	20x20x60
944-S	9605	944-W	15,850	23.60	18.10	58	3-5	20x20x65
1044-S	10,730	1044-W	17,700	26.35	20.85	58	4-5	20x20x70
1144-S	11,855	1144-W	19,550	29.10	20.85	58	4-5	20x24x70
1244-S	12,980	1244-W	21,400	31.85	23.60	58	4-5	24x24x70
1344-S	14,105	1344-W	23,275	34.60	23.60	58	4-5	24x24x75
1444-S	15,230	1444-W	25,125	37.35	23.60	58	5-5	24x24x75
1544-S	16,225	1544-W	26,770	40.10	23.60	58	5-5	28x28x75
1644-S	17,125	1644-W	28,250	42.85	23.60	58	5-5	28x28x80

The Vinco Company, Inc.

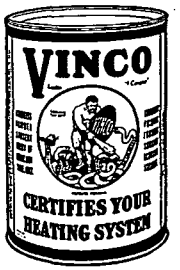
75 Vesey Street, New York, N. Y.

CABLE ADDRESS—Vincomp, New York

Vinco for Internal Cleansing of New, Remodeled and Old Heating Systems

Vinco Superfine Boiler Leak Seal





What Vinco Is

VINCO (Latin, "I conquer"), a positively harmless insoluble powder cleanser for new, remodeled and old heating systems.

What Vinco Does

VINCO permanently removes all the oil, grease, scale and dirt from the internal surfaces and from the boiler water *without the labor of blowing boilers over the top.*

By this thorough cleansing Vinco stops foaming, priming, surging, incomplete circulation and poor radiation.

The heating system is thus enabled to function in the best manner permitted by the design.

Cracked boiler sections, which most often result from priming, and sudden slugs of cooled water, are prevented.

How Vinco Works

Each minute grain of VINCO powder absorbs several times its own weight of oil, rust and dirt. These larger grains of absorbed impurities then settle and are blown through the bottom, according to directions on each can.

Vinco for all New and Remodeled Systems

Gives the heating system a clean bill of health from the start and puts every well-engineered system into first class operating condition before turning over to the owner. Use these specifications:

Vinco Specifications for Steam and Vapor Systems

Cleaning the System—Upon completion of the installation, the contractor shall clean the system by the VINCO method to remove oil, grease, rust and dirt from the boiler using,*.....lb. of VINCO, in exact accordance with manufacturer's directions.

This compound must remain in the boiler for 36 actual steaming hours, which corresponds to six or seven days average operation. At the end of this period, boiler must be thoroughly drained and flushed before refilling with clean water.

*In writing specification, insert in this space number of pounds of VINCO to be used in accordance with the following schedule. For systems having:

Up to	350	sq. ft. of	*radiation	3 lb.
351 "	600	" "	"	5 "
601 "	1100	" "	"	8 "
1101 "	1400	" "	"	10 "
1401 "	1800	" "	"	13 "
1801 "	2100	" "	"	15 "
2101 "	2700	" "	"	18 "
2701 "	3100	" "	"	20 "
3101 "	3700	" "	"	23 "
3701 "	4200	" "	"	26 "
4201 "	4600	" "	"	28 "
4601 "	5000	" "	"	30 "

Above 5000 sq. ft. use an additional pound of VINCO for each additional 300 sq. ft. of radiation.

*In determining amount of VINCO to be used all radiation may be taken at actual rating.

Vinco Specifications for Hot Water Systems

Cleaning the System—Upon completion of the installation, the contractor shall clean the system by the VINCO method using **.....lb. of VINCO in exact accordance with manufacturer's special directions for hot water systems, given on their cans.

**Only one half above quantities required for hot water systems.

Vinco for Old Systems

Annual cleaning of the old heating system adds years of life to the boiler, prevents rust deterioration and saves much fuel and fire attendance.

For old systems use only one half quantities given in specification table.

Our Free "Certified Chemically Correct" Laboratory Service

VINCO and the free services of the VINCO laboratories give you the assurance that the boiler water is chemically correct. Then if the boiler still foams, throws water or does not perform properly, it is time to look for mechanical flaws.

We promptly diagnose and permanently correct water line troubles due to impure water. Groping in the dark, guesswork, needless piping changes and recriminations are thus eliminated.

Our Three-fold Guarantee

1. VINCO contains no potash, lye, soda of any kind, oil, acid, or other harmful ingredients.
2. VINCO meets every performance claim. Purchase price is refunded if results are not entirely satisfactory when VINCO has been used according to directions.
3. Your time, money and comfort are further safeguarded by our free laboratory service which sees the most puzzling "water line" problem through with you if you wish.

Vinco Distributors

VINCO is distributed nationally by Burnham Boiler Corporation, Crane Company, United States Radiator, National Radiator. It is sold through leading jobbers in the United States.

Patents are pending upon the product and method o application. Unlawful imitation will be prosecuted.

Vinco Superfine Liquid Boiler Seal

A new and better leak seal, evolved by the same original research and authoritative science responsible for VINCO Boiler Cleanser. It will give the same prompt, sure results. It makes speedy and permanent repairs of all boiler and heating system leaks.

It is fine to tighten up new jobs. The directions are simple to follow.



QUANTITIES

Steam and Vapor Systems

Use 1 quart VINCO Liquid Boiler Seal to each 6 sq. ft. *grate* area.

Hot Water Systems

Use 2 quarts VINCO Liquid Boiler Seal to each 6 sq. ft. *grate* area.

The McDonnell & Miller
Self-Cleaning
Duplex Boiler Feeder

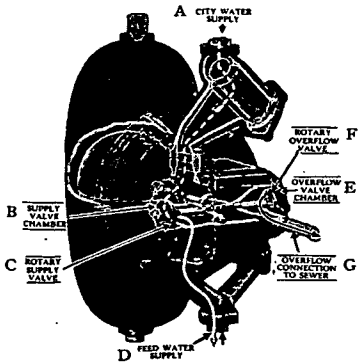
McDonnell & Miller

General Offices
Wrigley Building, Chicago
Grand Central Terminal, New York

Dependable Boiler Protection:

The McDonnell & Miller Self-Cleaning Duplex Boiler Feeder automatically maintains the correct water level in steam, vapor or vacuum heating boilers regardless of how hard the boiler is being pushed and even in the event that the condensation pump stops. Its action is totally independent of operating skill and attention.

By keeping the boiler water line where it belongs the McDonnell & Miller Duplex Feeder is a positive, mechanical protection against burned boilers or cracked sections.



How it operates:

City water enters feeder at (A), passes through large strainer and then to valve chamber (B).

When boiler water line drops, causing corresponding drop in float chamber, the float, in dropping, turns the rotary valve disc, thus opening the supply valve (C), allowing city water to pass through the manifold and into the boiler feed line connected at (D).

If condensation returning to the boiler causes water line to rise abnormally, a corresponding rise occurs in feeder float chamber. The float, in rising opens the rotary overflow valve (F) in overflow valve chamber (E), permitting excess water to discharge to sewer at (G).

Positive, Continuous Operation:

Continuous and dependable operation of the McDonnell & Miller Duplex Boiler Feeder is assured by these exclusive features:

1. Self-Cleaning Valves—cast bronze discs turning on Monel metal seats which grind and clean themselves every time float moves.
2. Full adjustment after installation—permitting a change in water line of one inch higher or lower, and an adjustment of differentials between supply and overflow levels of from 1 to 5 in.
3. Large Capacity—full city water pressure is put into the boiler feed line. The feeder will supply the entire requirements of any boiler even when condensation pump is not operating.
4. Greatest Simplicity—only one moving unit; fewer parts more finely made.
5. Complete oscillating movement on two bronze bearings, instead of sliding movement. Therefore, no possibility of sticking.

Service Conditions:

The McDonnell & Miller Self-Cleaning Duplex Feeder is adaptable to all low pressure heating boiler conditions.

The standard type is suitable for all boilers up to and including 14,500 sq. ft. where differential pressure is 30 lb. or above. For larger boilers, and where the differential pressure is low the McDonnell & Miller Special Type will be furnished.

Maximum allowable steam pressure is 20 lb. Water pressure should always be at least 5 lb. higher than steam pressure.

Each feeder is packed in sturdy, individual crate with complete instructions for installation.

Typical Specifications:

Furnish and install on each (low pressure heating) boiler One McDonnell & Miller Self-Cleaning Rotary Valve Duplex Boiler Feeder.

Rotary Valves to be adjustable to provide for a differential of from one to five inches between feed and overflow levels.

Self-Cleaning Duplex Feeders to have sufficient capacity for furnishing the entire amount of feed water required by the boiler when all of the condensation is wasted to the sewer, and at ..... lb. steam pressure and .....lb. city water pressure.

Installation to be made in accordance with diagrams and detailed instruction sheet furnished by the manufacturers.

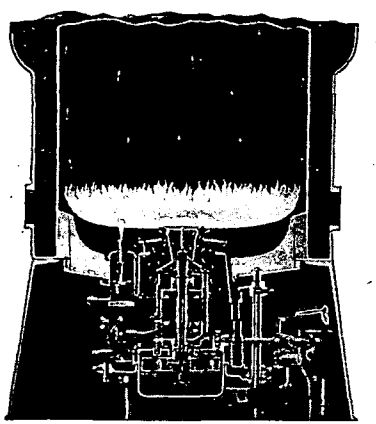
Automatic Burner Corporation

312 North May Street, **Chicago, Ill.**

ABC Automatic Oil Burner

The Automatic Burner Corporation are leading manufacturers of the rotary, in-the-ashpit type of oil burner. This principal—now acknowledged to be the simplest and most efficient for domestic oil burning—was originated seven years ago. Thousands of dollars have been expended in developing ABC, and its little brother, the Heat King, to their present simplicity and economical efficiency.

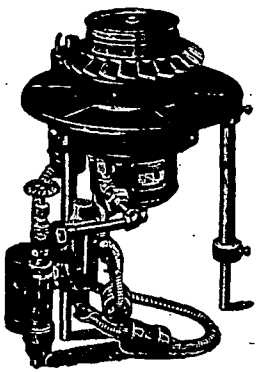
The Department of Engineering Research, University of Michigan, made some efficiency tests on June 15, 1928, with ABC installed in a DuBrie warm air furnace. ABC developed the high efficiency of 84.44 per cent.



Cross section of ABC in a round boiler

Heat King Automatic Oil Burner

Heat King is the burner for every man—for every man can afford the **Heat King.**



Heat King is the climax of seven years of concentrated research. Simple, rigidly built, economical to operate. Heat King is the burner for the man who counts his dollars and demands in return for them guaranteed satisfaction.

Write for more detailed information

	ABC	Heat King
Maximum Steam Radiation	3000	800
Price	$500 to $1000	$350 to $600

Ballard Oil Equipment Co.

Oil Burning Engineers and Contractors

NEW YORK PHILADELPHIA NEWARK

Factory Office

124 Branford Place, Newark, N.J.

And Agencies Throughout the United States



Installation of Ballard Type H Rotary Mechanical Burners in two 150-H. P. Simplex Boilers

The Ballard Oil Equipment Company offers a complete line of oil burning equipment for industrial and domestic installation. Its organization centers about its engineering service and its long experience in the field. To the architect, heating engineer and contractor this service is available in the form of expert engineering advice and the sale and installation of equipment which is perfectly adapted to the requirements of the individual job.

EQUIPMENT—

Owing to the many factors determining the suitability of an oil burning system to the requirements of a specific installation the various types of BALLARD burners differ widely in principle and characteristics, though they overlap generously in rating. We will gladly furnish full catalog data upon request, but where such is desired as data for a specific installation it would be well to furnish particulars sufficient to enable us to make a definite recommendation.

BALLARD equipment includes high pressure mechanical burners and steam atomizing burners for high pressure plants; the BALLARD Type H rotary mechanical burner for fuel of 12 to 16 deg. Baumé for use in low pressure heating plants of the larger class, the BALLARD Type H pump type burner for fuel of 19 deg. Baumé or higher for similar service where it is impractical to use the heavier fuel; the BALLARD Type A automatic oil burner for large residential and semi-industrial use, and automatic residence burners.

The Ballard Oil Equipment Company is also in a position to make special application of oil burning to industrial uses apart from heating and power.

Factory Branches:
CHICAGO
549 N. Michigan Ave.
BOSTON
843 Beacon Street

Hardinge Brothers, Inc.

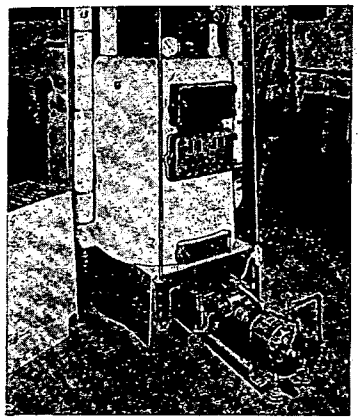
"The Oil Burner with a Ten-Year Guarantee"

Main Office and Factory

4149 Ravenswood Avenue Chicago, Ill.

Branches and Dealers in Principal Cities throughout the United States

Manufacturers of HARDINGE Domestic and Industrial Oil Heating Equipment, Cataract Precision Lathes, Watchmakers and Opticians Tools and Supplies



Hardinge Brothers, Inc., manufacture a range of Oil Heating Equipment adaptable to Heating the Boiler with steam radiation loads of 500 to 25,000 sq. ft. per unit. It has been the aim of this organization not just to put another Oil Burner on the market, but to build into the HARDINGE the finest that material, workmanship, sound design, ample capital and more than one-third century of Precision experience could build. Architects, Heating Engineers and Contractors should feel free to call upon our Engineering Department for information of any kind on Oil Heating problems anywhere.

SEE OUR CATALOGUE IN SWEETS

Features:—

1—Mechanical Centrifugal Atomization without the use of fans, blowers, compressors or steam.

2—Applies heat at grate level, scrubbing insulating gases from water legs.

3—It is a self contained unit independent of the Combustion Chamber and not attached to the boiler in any way.

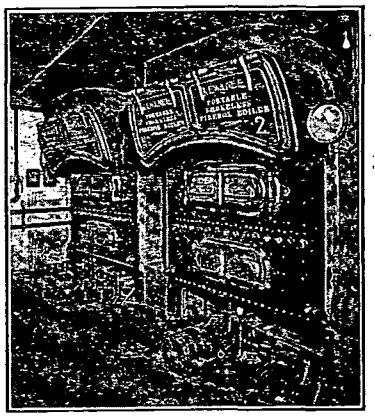
4—Burns automatically any commercial fuel oil available between 28 and 40 deg. A.P.I. Burns manually fuel oil between 18 and 40 deg. A.P.I.

5—Fuel Feeding Valve *self cleaning* in its operation.

6—Motor—Standard, horizontal, constant speed (1750 r.p.m.) motor operating under normal temperature conditions.

7—Approved by the *National Board of Fire Underwriters;* Tested and Approved by the New York City Board of Standards and Appeals.

8—Tested over a period of ten years by the ultimate judge of Oil Heat—the User Public who also approve.



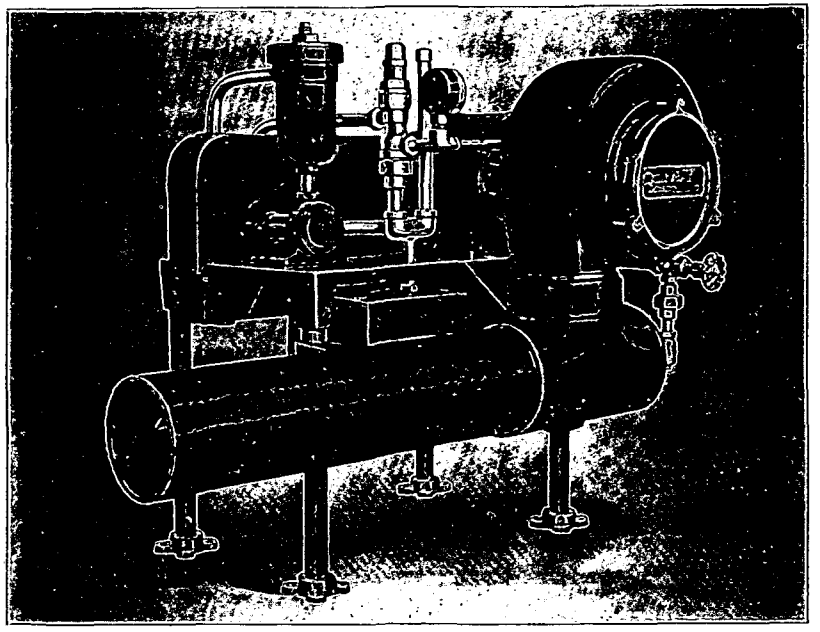
Ratings			HARDINGE ATOMIZER-SIZES	Ratings		
Atomizers Diam. Inches	Capacity in Sq. Ft. Steam Load	Motor H. P.		Atomizers Diam. Inches	Capacity in Sq. Ft. Steam Load	Motor H. P.
3	500	1/4		6	4800	1/2
3 1/2	800	1/4		6 1/2	5500	3/4
4	1200	1/4		7	6500	3/4
4 1/2	2000	1/4		8	10,000	1
5	3000	1/3		9	15,000	1 1/2
5 1/2	3800	1/3	"FROM BUNGALOW TO SKYSCRAPER"	10	25,000	1 1/2

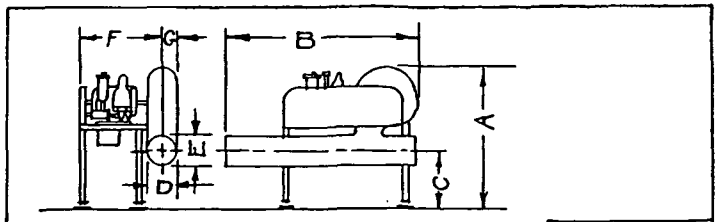
May Oil Burner Corporation

Factory and General Offices
Baltimore, Md.

New York Office
331 MADISON AVENUE

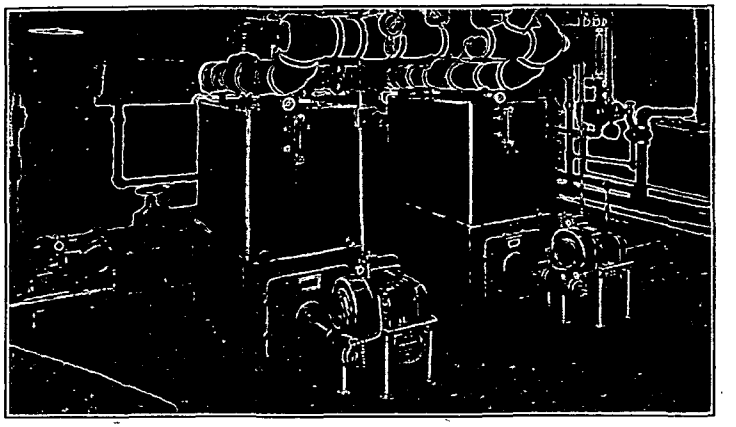
Chicago Office
PURE OIL BUILDING
35 EAST WACKER DRIVE





TYPE	A	B	C	D	E	F	G	MOTOR	MINIMUM GAL PER HR.	MAXIMUM GAL PER HR.
A	22"	30"	9½"	4¼"	4¼"	12"	2"	⅛ H.P.	1½ GAL.	2 GAL.
L	24"	32"	9½"	4¼"	4¼"	17"	2½"	¼ H.P.	1½ GAL.	7½ GAL.
C	26"	30"	13¾"	6¼"	6¼"	3¾"	18"	½ H.P.	7½ GAL.	30 GAL.

Quiet MAY *Automatic* Oil Burner



THE Quiet MAY Automatic Oil Burner is a fully automatic oil burner, suitable for either domestic or commercial operation, in steam, hot water, vapor or warm air heating plants.

(1) Mechanical draft pressure atomizing burner. A. C. or D. C. motor drive. Intermittent operation. Completely automatic or manual control.

(2) Listed to burn 28 gravity oil (A. O. B. A. Spec. No. 3) or 25 gravity Pacific Coast Diesel oil.

(3) Oil is brought from storage tank by suction pump on burner which delivers it under pressure to the atomizer.

(4) Atomization is by specially designed mechanical pressure atomizer.

(5) Ignition by electric spark.

(6) Flame can be adjusted as to size and shape to meet requirements of boiler or furnace.

(7) Only changes required are removal of grates, and lining of combustion chamber with fire brick.

(8) Made in three sizes—for domestic and commercial installations. Adaptable to small homes and to large apartment buildings.

(9) Motor sizes: Type A—⅛ H.P. Type L—¼ H.P. Type C—½ H.P.

CAPACITIES

	Type "A"	Type "L"	Type "C"
Steam	600 sq. ft.	2400 sq. ft.	8400 sq. ft.
Hot Water	1000 sq. ft.	4000 sq. ft.	14000 sq. ft.

Petroleum Heat & Power Company

Makers of Oil Burners Since 1903

PETRO

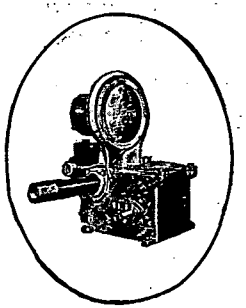
DOMESTIC AND INDUSTRIAL OIL BURNERS

Main Office—511 Fifth Avenue, New York, N. Y.
Factory—110 Davenport Street, Stamford, Conn.

Branch Offices at

Boston San Francisco Seattle Providence Los Angeles Portland, Ore.

National Sales and Service Organization



PetrO Burners are all of the mechanical atomizing type and are built in such a number of models and sizes as to cover the heating field from the smallest residence to the largest commercial or industrial heating plant. PetrO Burners are adaptable to any standard type of boiler or heater and can handle from a small heating load of 200 sq. ft. of steam radiation to 375 b.hp. with one burner.

DOMESTIC BURNERS

PetrO Domestic Burners are of the air turbine driven rotary cup type and are fully automatic and of the intermittent firing type. Standard Minneapolis-Honeywell controls are used throughout. PetrO Domestic Burners are designed to burn commercial fuel oils having a gravity of not less than 24 degrees Baumé and a viscosity of not more than 50 seconds Saybolt Universal at 100 deg. fahr. Ignition is accomplished by means of either an electric spark or by means of a gas-electric type of ignition.

The PetrO Burner is designed and built to operate with a minimum of mechanical and combustion sound. It consists essentially of a centrifugal fan constructed with a shrouded aluminum runner, completely balanced and housed in a cast aluminum fan case. Mounted on the fan case and direct connected to the fan runner is an electric motor. Also driven from the motor shaft either through reduction gearing or by direct connection is a rotary gear oil pump. This assembly is mounted on a base built of grey cast iron in which is built a float chamber. Inserted through the base directly under the fan outlet is the burner gun, the forward end of which terminates in the air register which is installed flush with the boiler ashpit opening. The gun comprises the atomizing

PETRO OIL BURNERS

cup which rotates in ball bearings, oil connection from float chamber to atomizing cup, lubricating device for ball bearings and air connection for conveying air from fan through the cup turbine and past vanes for mixing the air with the atomized oil in the combustion chamber.

Oil is drawn from the storage tank by the pump through a brass suction line and delivered into the float chamber where a constant level of oil is maintained. The pressure of the fan is communicated to the float chamber and acts to lift the oil to the atomizing cup. The air is delivered past the turbine blades of the cup for atomizing the oil and finally into the combustion chamber for supporting combustion.

The standard installation includes a thermostat for controlling building temperature, a combustion safety control and a boiler or furnace control for limiting temperature or pressure conditions at the boiler or furnace.

Service hot water may be heated from the main heating boiler through standard indirect heaters during both summer and winter.

PETRO Domestic Oil Burners are manufactured in the following models and capacities:

Burner Model	Gallons of Oil per Hour	Maximum Square Feet Steam Radiation	Maximum Square Feet Water Radiation	Boiler H. P.	Motor H. P.
LD-00	¾ to 1½	625	995	....	⅛
LD-0	½ to 2½	1,025	1,650	....	⅛
LD-1	2½ to 5	2,075	3,325	....	1/6
LD-2	5 to 10	4,150	6,650	....	⅓
LD-3	10 to 20	8,300	13,275	65	½
*LD-4	20 to 42	17,425	27,900	140	1

*Gas-electric Ignition only.

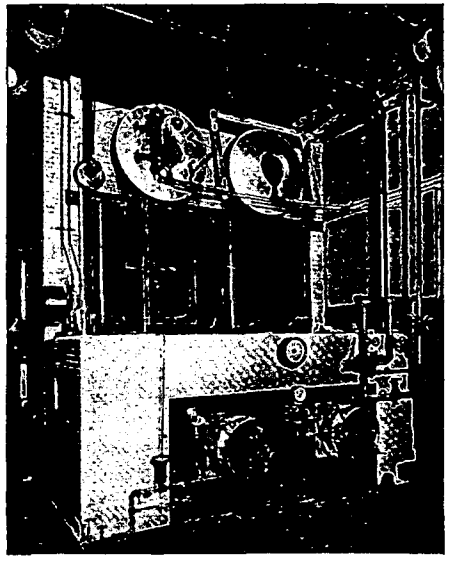
The PETRO Domestic Oil Burner is:

Listed as Standard by The Underwriters' Laboratories, Inc.
Approved by the Board of Standards and Appeals, New York City, New York.
Approved by The Commonwealth of Massachusetts, Department of Public Safety.
Approved by State of Connecticut, Department of State Police.
Approved by the Investigating Committee of Architects and Engineers.

PETRO OIL BURNERS

TYPE "A" INDUSTRIAL OIL BURNING EQUIPMENT

All PETRO Industrial Burners are designed to burn oils as heavy as 10 degrees Baumé. PETRO Type "A" Burners are of the air turbine driven rotary cup type and are installed on boilers in connection with Type "A" registers through which secondary air for combustion is admitted and is controlled as to volume and direction. The primary air for driving the turbine cup and atomizing the oil is delivered from a centrifugal fan which is a separate unit. One fan may thereby be used to operate either one burner or several burners installed in a battery of boilers. The oil pump is also separate from the burner and one pump may also be used for one burner or a multiple installation of burners. In Petroleum Heat and Power Company's Combination Fan and Pump Set both the fan and pump may be operated as one unit driven by a single motor. The fan and pumps are obtainable as separate units also and for either electric motor or steam turbine drive.



PETRO *installation in Metropolitan Life Insurance Co. Building—One Boiler—Two-Type "A" Burners.*

Design of the air register is such that the flame can be shaped to suit furnace dimensions and assure intimate mixing of the air and atomized oil. High efficiencies are thereby obtainable and can be maintained at 80 per cent with proper care of operation.

This type of burner possesses a wide range of flexibility as to the capacity at which it can be fired and without the necessity of changing any parts. One or more burners may be installed under a boiler depending upon the capacity to be developed.

It is adaptable to semi-automatic control wherein the rate of firing can be varied between low and high capacity by means of an automatic boiler control which operates from the boiler steam pressure. Oil is delivered to the atomizing cup at a relatively low pressure which ranges between 10 and 35 pounds per square inch.

In burning the heavier grades of fuel oil it is necessary to preheat the oil so as to reduce its viscosity as a means of obtaining the necessary fineness of atomization.

In PETRO Type "A" Burners the required preheat temperature is relatively low, as, for burning oil having a gravity of 10 degrees Baumé, a preheat temperature of 170 deg. fahr. is sufficiently high.

PETRO

Capacities of Type "A" Burners

Burner Model	1A	2A	3A	4A
Minimum Capacity (B. H. P.)	25	50	100	125
Maximum Capacity (B. H. P.)	55	175	300	375

PETRO *Type "A" Equipment is:*
Listed by The Underwriters' Laboratories, Inc.
Approved by The Board of Standards and Appeals, New York City, New York.

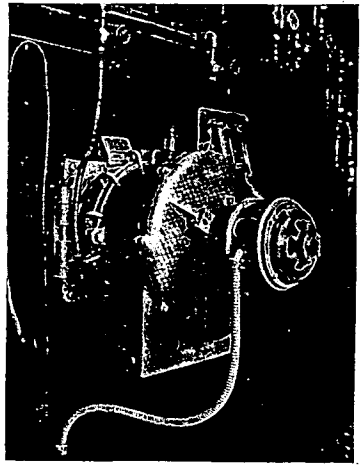
TYPE "B" INDUSTRIAL OIL BURNING EQUIPMENT

The PETRO Type "B" Burner consists of an air turbine driven rotary cup, air register and fan with direct connected motor, all of which are assembled in one unit to be hinge mounted on the boiler front. The principles of atomization and means of driving the turbine cup are the same as employed in the Type "A" Equipment. Oil is delivered to the burner from an independent pump.

This unit is well adapted for installation in heating or power plants having one or two boilers and it also lends itself particularly to semi-automatic boiler control.

The design of the air register allows control of flame shape to the combustion chamber being fired and provides for securing the degree of mixture between the air and oil necessary for the most efficient combustion.

This type of burner also possesses a wide range of flexibility as to the amount of oil that can be burned and it is not necessary to change burner parts for various rates of firing.



Type "B" Burner in B & W Boiler

As with the Type "A" Equipment the oil is pumped at a relatively low pressure and the temperature of preheat is low.

Capacities of Type "B" Burners

Burner Model	1B	2B	3B
Minimum Capacity (B. H. P.)	30	50	75
Maximum Capacity (B. H. P.)	75	150	250

PETRO OIL BURNERS

MECHANICAL TYPE INDUSTRIAL OIL BURNING EQUIPMENT



Municipal Building
New York City

The mechanical type burner atomizes the oil by pumping it at a relatively high pressure through atomizing grooves and an orifice located in the burner head. The oil is forced through the grooves in the atomizer disc toward the center where it enters tangentially and by means of which a rotary motion is imparted to it as it expands through the atomizing orifice.

The mechanical burner is also installed in connection with an air register, the purpose of which is to control the volume and direction of the secondary air supply. The degree of mixture between air and oil which is attainable through the proper setting of the register lends itself to operation at high efficiency of combustion.

Pumping and heating equipment may be located at some distance from the boiler or in a separate room.

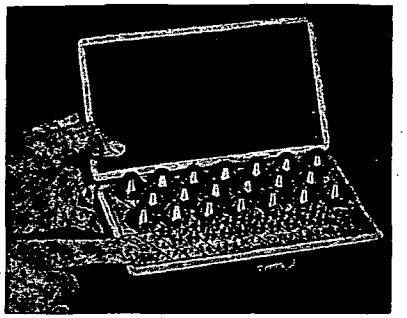
By the installation of more than one burner in each boiler or the use of forced draft apparatus, boilers of any rating may be fired.

Variations in burner capacities are obtained by the use of different combinations of atomizer and orifice discs. By the use of these combinations and variations in pressure capacities of from 50 to 300 b.hp. may be obtained from one burner under natural draft conditions. By the use of forced draft this capacity may be increased to 400 b.hp.

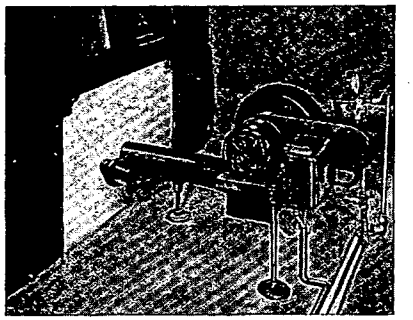
Winslow Boiler & Engineering Co.

Builders of* Kleen-Heet *Oil Burners

CHICAGO	NEW YORK	GALESBURG
844 Rush St.	11 W. 42nd St.	Illinois



The Nozzle Kit



A Typical "805" Installation

FOR years the Winslow Boiler & Engineering Company has carried on intensive research work. This engineering work has been made highly accurate through the use of modern scientific methods, and in a wide variety of boilers and furnaces covering every type found in practice. The experience of its laboratory engineers has been gained through actual oil burner field work.

FOR efficient heating a burner must be of correct size for the size of building it is called upon to heat. Recognizing this fact, Winslow makes four distinct types of heating equipment. There is literally no building for which there is not a corresponding size or model. For huge industrial plants and industrial uses, there is the Winslow Industrial Burner; for large apartments, hotels, business blocks, churches, and other public or semi-public buildings, as well as large homes, there is a range of installations called the 800 Series, explained below. Just under the 800 Series is the "GJ" model, and for the smaller home, the "CHALLENGER" model KLEEN-HEET has been provided.

SERIES 800 KLEEN-HEET

FULLY AUTOMATIC: The fully automatic operation of this burner means uniform heat, real health, fuel economy, and all without worry and attention. Equipment includes protectostat, thermostat and boiler control.

ELECTRIC IGNITION: Positive electric ignition without magneto or coil box. High tension transformer with two insulated electrodes provide automatic, positive electric ignition and completely eliminates RADIO INTERFERENCE.

NOISELESS: Sound reduction to a minimum is accomplished by the simple engineering method of utilizing perfectly machined, smooth running, properly built parts. The KLEEN-HEET 800 is so designed that the correct air volume moves at low velocity, thus eliminating—not merely subduing—combustion noise.

EFFICIENT: Combustion efficiency is gained through the perfection of KLEEN-HEET equipment. Burner perfection is brought to its maximum through the use of the Winslow patented nozzles: nine different nozzle tips to determine the size and shape of the flame: eight different nozzle stems to control the volume of oil delivered. The resultant 72 tip-stem nozzle assemblies enable the engineer to select that combination which gives maximum efficiency. In this way a proper flame can be produced regardless of the length or width of the combustion chamber: this feature is a remarkable advance, in fact one of the greatest, in the oil burner industry.

CAPACITY RANGE: This ONE burner covers the entire capacity range from 600 to 6800 sq. ft. of steam load.

FUEL OIL: 28 deg. Baumé or lighter fuel oil with flash-point between 150 to 190 deg. and a cold test sufficient to resist the lowest temperatures to which it will be subjected, is the ideal fuel for this burner.

SERVICE: The burner is particularly characterized by the thoroughness of installation instructions and the least possible number of working parts, each part the best obtainable without regard to cost of production.

SMOKE ABATEMENT: Many cities are demanding the eliminating of fuel which increases the smoke nuisance; oil is the logical smokeless fuel; the "805" KLEEN-HEET meets those requirements.

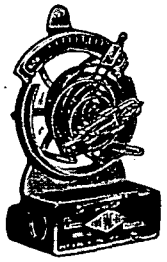
Listed as Standard by Underwriters' Laboratories

ABSOLUTE CON-TAC-TOR CORPORATION

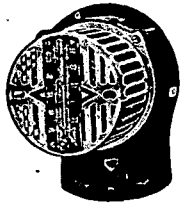
ELKHART, INDIANA

Manufacturers of Temperature and Pressure-Operated Automatic Electric Controls, Mercury Switches and Safety Devices for Oil and Gas Burners

AUTOMATIC CONTROL FOR UNIT HEATERS



No. 26AR Convoswitch
List Price, $20

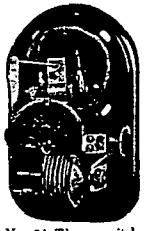


No. 135 Thermoswitch
List Price, $18

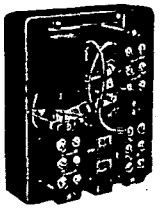
The Thermoswitches

The three Thermoswitches shown automatically control the fan motors of Unit Heaters as the room temperature varies. They all include Mercury Switch contact members. The Convoswitch is particularly fitted for the control of factory rooms, warehouses, greenhouses, etc. The Nos. 64 and 135 are particularly arranged for rooms requiring closer temperature control and more pleasing appearance. These Thermoswitches should be used in auditoriums, offices or similar places. The No. 135 Thermoswitch is low in electrical capacity and should only be used with the No. 112 Magnetic Relay. It is, however, very sensitive and will regulate the temperatures to 1 deg. variation. The No. 64 is a 2 deg. instrument but is higher in electrical capacity and will control motors of ½ hp. or less (single phase) without a relay.

The Magnetic Relay is made in single or double pole types and will be found an excellent across-the-line starter for most of the sizes of motors used on Unit Heaters.



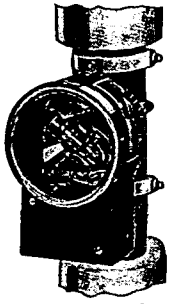
No. 64 Thermoswitch
List Price, $24



No. 112 Magnetic Relay
List Price, $12

The Limit Controls

It is not desirable to operate the Unit Heater unless its coils are hot enough to warm the outgoing air. Therefore, with automatic operation we recommend the use of a Limit Control. When wired in series with the Thermoswitch, the Limit Control prevents the Unit Heater from starting until it is warm. However, when the Heater is warm, the Limit Control, turns over the entire regulation to the Thermoswitch until such time as the Heater gets cold when the Limit Control again takes command and shuts it down.



No. 56 Aquaswitch
List Price, $17.50

Limit Controls are available to operate either from the temperature of the steam pipe or the pressure of steam at the Unit Heater. The most popular control is the No. 56R Aquaswitch which can be strapped on the pipe leading to the Heater. No drilling or draining is necessary to install this control and it works successfully on either steam or hot water systems.

The No. 33R Pressureswitch or No. 42R Vaporswitch can be used where it is desired to control the Unit Heater from variations of the steam or vapor pressure.

These Controls are Completely Described in BULLETIN 141
—WRITE FOR YOUR COPY—

BULLETIN 101—**Mercury Switches**
BULLETIN 111—**Oil Burner Controls**
BULLETIN 121—**Refrigeration Controls**
BULLETIN 131—**Coal Burner Controls**

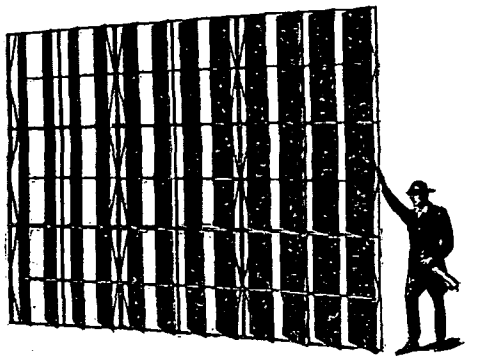
American Foundry & Furnace Company

Bloomington, Illinois

Manufacturers of "AFCO" Ventilating Specialties, W. A. Diffusers, Grilles, Back Pressure Dampers, Expanded Metal Screens, Access Doors, Baseboard Grilles (K-515, etc.), Miscellaneous Dampers, Belt Guards. Blast Systems of Warm Air Heating and Ventilating

"AFCO" LOUVRE DAMPERS

For Installation in Fresh Air Openings in Walls of Power Houses, Hotels, Theatres, Churches, Schools, Etc.



F-17G

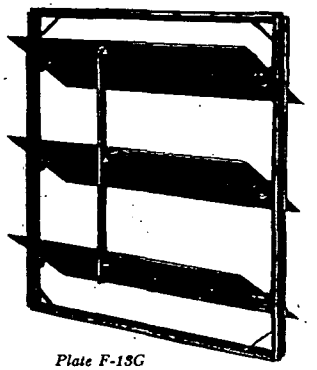


Plate F-13G

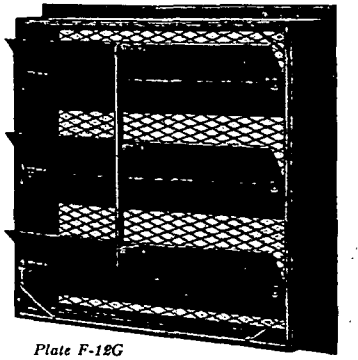


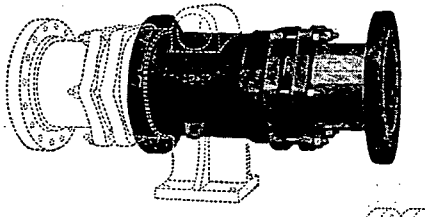
Plate F-12G

Made to fit any size opening. Blades Horizontal or Vertical.
Hand or Automatic Control. Dampers open and close in unison.
Ball Bearing Axles unless otherwise specified.
Maximum Free Areas producing Minimum Air Resistance.
Superior Strength and Ruggedness. Black Enamel Finish.
F-17G—Large Three Panel Unit without Screen.
F-12G—With reinforced Channel Iron Frame.
F-13G—With 6 in. deep frame and Wire Screen.

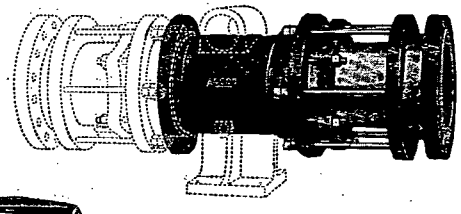
AMERICAN DISTRICT STEAM COMPANY

GENERAL OFFICES AND WORKS
NORTH TONAWANDA, N.Y.

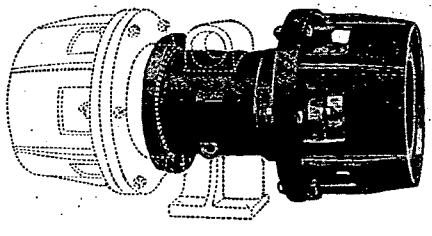
Branches and Agents in Principal Cities



AT LEFT—**ADSCO** Semi-Guided Expansion Joint for 4, 6, 8, 10 and 12 in. traverse, 125 and 250 lbs. pressure. Below: same joint with tie rods.

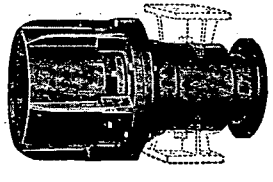


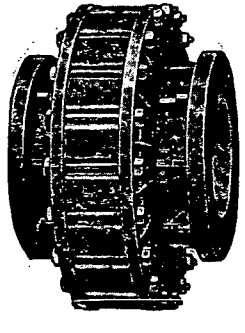
The dotted lines illustrate some of the combinations of **ADSCO** Expansion Joints.



AT LEFT—**ADSCO** Externally-Guided Expansion Joints for 4, 6, 8, 10 and 12 in. traverse, 125 and 250 lbs. pressure.

AT RIGHT—**ADSCO** Duplex-Sleeve Guided Expansion Joint for pressures up to 500 lbs. and temperatures to 750 degrees F. Air-cooled slip eliminates excessive packing and maintenance costs and assures a tight joint.





AT LEFT—**ADSCO** Model "P" Variator (Packless Expansion Joint) for pressures up to 125 lbs. Total traverse 2 in. Not furnished with service outlets nor anchorage.

Model "O" Variator (not illustrated) single with 1⅜ in. traverse and double with 2¾ in. traverse for pressures up to 50 lbs. Built with service outlets and anchor plates.

ADSCO Variators absorb expansion and contraction in pipe line with heavy annealed corrugated copper diaphragms supported by steel backing plates.

E. B. Badger & Sons Co.

63-75 Pitts Street, **Boston, Mass.**

Engineers and Manufacturers

NEW YORK OFFICE, 271 Madison Avenue — OFFICES IN PRINCIPAL CITIES

PRODUCTS

Corrugated Copper Expansion Joints
Pipe Bends
Chemical Apparatus
Copper and Sheet Metal Work
Copper Boilers

BADGER SELF-EQUALIZING EXPANSION JOINTS

Made in flanged and welding types. Both have one-piece copper expansion element, corrugated by a special process and fitted with external cast iron or steel equalizing rings between the corrugations to uniformly distribute the movement among all the corrugations to minimize wear. There are no stuffing boxes or sliding joints. No packing is required. Guaranteed to 200 lb. working pressure up to 3 in. expansion for a single joint.

Flanged Types



For saturated steam, hot water and other hot liquids, in sizes 4 in. and 5 in. Made with 4 to 8 corrugations for 1 or 2 in. expansion respectively. Fitted with alignment bars. Flanges may be of low, standard or extra heavy types. Face to face dimensions both sizes:—12⅝ in. for four corrugations, 19⅞ in. for eight corrugations.



For Saturated Steam



For Superheated Steam with Telescoping Monel Metal Sleeve

For sizes 6 in. pipe and larger. Made with 2, 3, 4 or 5 corrugations for 1, 1½, 2 or 3 in. expansion. Either standard 125 lb. or extra heavy 250 lb. flanges as required. Sizes larger than 30 in. furnished on special order.

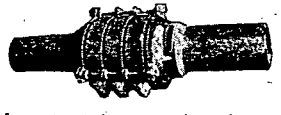
Self-Equalizing Expansion Joints—Standard Flanged Types

Face to face dimensions in inches

Size	Number of Corrugations			
	2	3	4	5
6	12½	16	19	23
8	12½	16	19	23
10	12½	16	19	23
12	13	16½	19½	23½
14	13½	17	20	24
16	13½	17	20	24
18	14	17½	20½	24½
20	15	18½	21½	25¼
22	15	18½	21½	25¼
24	15½	19	22	25¾
26	15½	19	22	25¾
28	15½	19	22	25¾
30	15½	19	22	25¾

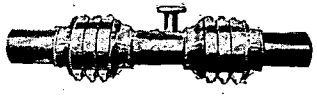
Dimensions of saturated and superheated steam oints are identical.

Welding Type



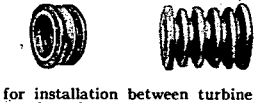
Made for saturated or superheated steam with open pipe nipples for welding directly into the pipe line.

Single Joints:—For 3 and 4 in. pipe have 4 and 8 corrugations, for 1 or 2 in. expansion, respectively. For sizes 5 to 20 in. pipe they have 2, 3, 4 or 5 corrugations for 1, 1½, 2 or 3 in. expansion respectively.



Double Joints:—Similar to single type, consisting of two single expansion joints welded together in tandem. Made with 4, 6, 8 and 10 corrugations, for 2, 3, 4 and 6 in. expansion respectively. Can be equipped with service connections. Also furnished as complete units, mounted on base plate, together with anchor and guides.

Single and Multiple Corrugated Expansion Joints for Low Pressure

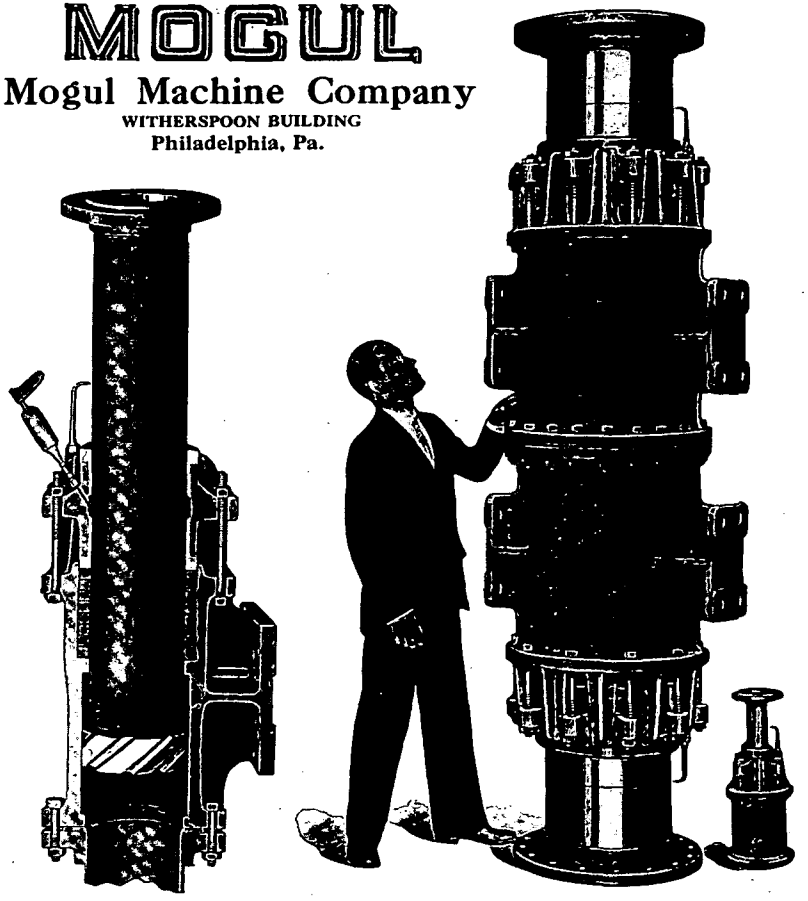


Made for installation between turbine or engine exhaust and condenser, or to take up expansion in low pressure lines. They absorb shock and vibration and are a dependable protection for costly equipment. Furnished with 1 to 5 corrugations and low or standard flanges. Also in rectangular or oval form to meet special requirements. Guaranteed for pressures to 30 lb.

MOGUL

Mogul Machine Company

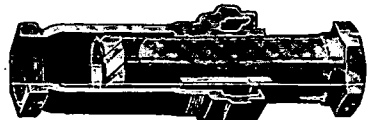
WITHERSPOON BUILDING
Philadelphia, Pa.



"MOGUL" DOUBLE-END-GUIDED, TYPE F. L. J. (FLANGED) EXPANSION JOINTS

Built in all pipe sizes from 1½" to 6' diameters, for extremely high or low pressures and temperatures, for saturated steam, superheated steam, hot or cold water, oil or gas and other fluids.

They are Double-End-Guided, have extremely deep packing chambers and unusually long packing-gland take up. They have built-in Traverse Stops and large graphite lubricating chamber. They may be packed while the line is hot and in an expanded condition. *Write for Bulletin with complete description and dimensions.*



"MOGUL" DOUBLE-END-GUIDED, TYPE R. S. J. (RISER) EXPANSION JOINTS

Built with screwed ends, in all pipe sizes from ¾" to 4" pipe diameters. *Write for Bulletin and dimensions.*

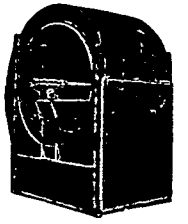
American Blower Corporation

General Offices: **Detroit**

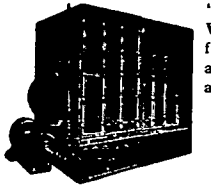
Works: DETROIT, MICH.—BOND HILL, CINCINNATI, OHIO

Branches and Sales Offices

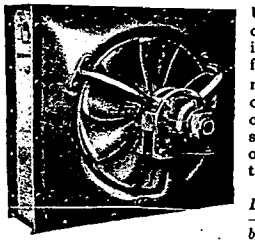
City and Address	Telephone
ATLANTA, GA., Bona Allen Bldg.	Walnut 5643
BALTIMORE, MD., Munsey Bldg.	Plaza 3774
BIRMINGHAM, ALA., American Traders Bank Bldg.	7-2383
BOSTON, MASS., 1003 Statler Bldg.	Liberty 8347-48
BUFFALO, N. Y., White Bldg.	Seneca 2668
CHARLOTTE, N. C., Piedmont Bldg.	Jackson 122
CHATTANOOGA, TENN., 1104 James Bldg.	Main 2679
CHICAGO, ILL., 228 N. La Salle Street	Central 1631-1632
CINCINNATI, OHIO, 905 Sycamore Street	Canal 8161-8162
CLEVELAND, OHIO, 1302-3 Swetland Bldg.	Main 6846
COLUMBUS, OHIO, 521 First Nat'l Bank Bldg.	Main 3443
DALLAS, TEXAS, 1015 Mercantile Bank Bldg.	X-5518
DAVENPORT, IOWA, 409 First Nat'l Bank Bldg.	Dav. 4006
DENVER, COLO., 1226 California Street	Main 5818
DETROIT, MICH., 2539 Woodward Avenue	Cadillac 8880
EL PASO, TEXAS, Border National Bank Bldg.	Main 2739
GRAND RAPIDS, MICH., 604 Building and Loan Bldg.	Citizens 51122
HARTFORD, CONN., 252 Asylum Street	2-2027
INDIANAPOLIS, IND., 819 Continental Bank Bldg.	Lincoln 6745
KANSAS CITY, MO., 310-312 Mutual Bldg.	Victor 5965
LOS ANGELES, CALIF., 427 Union Ins. Bldg.	TUcker 9440 / FAber 3871
LOUISVILLE, KY., 428 S. Fifth Street	City 3100-1
MILWAUKEE, WIS., 1418 Majestic Bldg.	Grand 1986
MINNEAPOLIS, MINN., 808 La Salle Avenue	Main 0034
NEWARK, N. J., 79 Ogden Street	Branch Brook 8540
NEW ORLEANS, LA., 344 Camp Street	Main 5971
NEW YORK, N. Y., 50 Church Street	Cortlandt 1010
NEW YORK (Export Dept.), 30 Church St.	Cortlandt 4856
OMAHA, NEBR., Peters Trust Bldg.	ATlantic 6548
PHILADELPHIA, PA., 112 South 16th Street	(Bell) Rittenhouse 6393-4
PITTSBURGH, PA., 801 First Nat'l Bank Bldg.,	Atlantic 3496-3497
PORTLAND, OREGON, 1002 Pacific Bldg.	BEacon 6197
READING, PA., 506 American Casualty Bldg.	Reading 37112
ROCHESTER, N. Y., 89 East Avenue	Stone 345-346
ST. LOUIS, MO., 1221 Boatmen's Bank Bldg.	Garfield 1278
SALT LAKE CITY, UTAH, Dooly Bldg.	Wasatch 1680-1681
SAN FRANCISCO, CALIF., Rialto Bldg.	Sutter 1024
SEATTLE, WASH., 605 Leary Bldg.	Eliott 0713
SCHENECTADY, N. Y., 331 State Street	Schenectady 7503
SOUTH BEND, IND., 505 Pythian Bldg.	3-5455
SYRACUSE, N. Y., 1200 Hills Bldg.	3-0170
TACOMA, WASH., 1127 St. Paul Avenue	Main 3150
TOLEDO, OHIO, 320 Ontario Street	Adams 6512
WHEELING, W. VA., 114 18th St., Warwood, Warwood 375W	
WILKES-BARRE, PA., Miners' Bank Bldg., Wilkes-Barre 4824	
YOUNGSTOWN, OHIO, 1008 Mahoning Bank Bldg.	4-3593



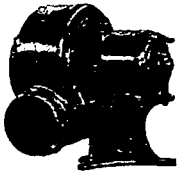
"Sirocco" Fans and Blowers for heating, ventilating, cooling, drying and mechanical draft.



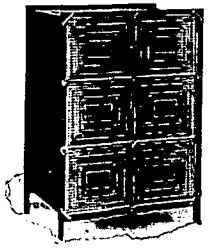
"Sirocco" Air Washer — for purifying and humidifying air for dehumidifying and cooling.



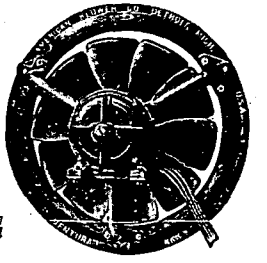
Venturafin Unit Heater—one small unit is equal to 500 feet of direct radiation—occupies only one-fourth the space and has only one-tenth the weight.



"Sirocco" Utility Blower—a compact, durable ventilator for installation with ducts.



A. B. C. Air Filter—Dry plate constant effect air filter—a highly efficient device for collecting dust in public and industrial buildings of every type and description.



"Ventura" Disc Fan for operation under free-air delivery conditions — a complete ventilation system in itself.

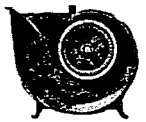
Descriptive folders on any subject of air handling—heating, ventilating and mechanical draft will be furnished free on request.

Bayley Blower Company

784 Greenbush Street **Branches in Principal Cities** **Milwaukee, Wis.**

BUILDERS OF HEATING, VENTILATING, COOLING, PURIFYING, HUMIDIFYING AND AIR WASHING EQUIPMENT; EXHAUST AND DRYING APPARATUS, MECHANICAL DRAFT AND BLAST, FANS AND BLOWERS OF ALL TYPES

BAYLEY PLEXIFORM FAN:



Used to supply air for heating systems or heating and ventilating systems for manufacturing and process industries, for drying systems, or for forced or induced draft systems for boiler plants.

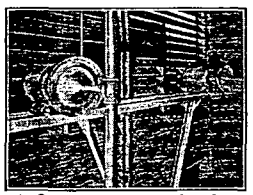
The Plexiform Fan is suitable for handling cool or warm air, as well as high or low temperature gases. It will deliver the maximum quantity of air in applications where medium or low pressure is required.

For applications where space is limited, or where economy of power is desirable, this fan is especially recommended.

The fan wheel, of distinct Bayley design, has great strength without excess weight. Due to its reinforced construction and equal distribution of stresses, vibration is reduced to a minimum. Crystallization of parts, so called, is thus avoided. Large and unobstructed inlets and outlets, and the absence of arbitrary air cut-offs, insure free and noiseless delivery of air.

Bayley Plexiform Fans are furnished in either single or double width wheel types of any required housing construction, and discharge positive sleeve or ball bearings as specified.

TURBO AIR WASHER AND HUMIDIFIER:



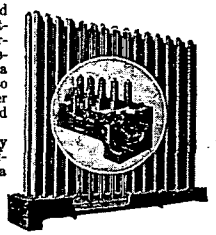
The Bayley Turbo Air Washer Showing Turbo Atomizer and Eliminator

The Bayley Air Washing System is offered for all public and industrial buildings, where a central system of air washing and humidifying is desired.

Competitive air washing and humidifying equipment requires frequent cleaning of the spray nozzles, as the particles of dirt in the recirculated water rapidly clogs the orifices.

The Turbo Atomizer used in the Bayley Washer, produces a steady, fine spray. Water at low pressure is delivered to the center of a rapidly revolving cone-shaped rotor provided with atomizing pins set in its periphery. This atomizer cannot clog, requires very little attention, and will operate successfully under low water pressure. The spray is uniform, and there are never any spaces in the Air Washer that are not completely filled with a fine mist. Bayley Turbo Air Washer and Conditioners may be used for washing, cooling, humidifying, or dehumidifying, as required.

CHINOOK HEATING SECTIONS:



The Chinook Section is used with fan type heating, ventilating, and drying systems. It circulates either high or low pressure steam by gravity or under a vacuum. The heater may also be used to circulate hot water for heating purposes, or cold water for cooling purposes.

The Chinook base is of grey cast iron, having walls of sufficient thickness to withstand a working pressure of 175 lb. per sq. in. The casting is divided into two chambers by a horizontal partition. Steam enters the lower or steam chamber from which it rises through ¾-in. wrought pipes, which are located within the 1¼-in. wrought pipes leading from the upper chamber. Thus the steam in the steam chamber passes up through the small pipes (which are open at the top) into the larger pipes, where condensation takes place, the water and air falling into the upper chamber and draining away through the return outlet. Each tube is evenly heated through its entire length, and air binding cannot occur. The Chinook is the only heater in which a leak can be repaired in the middle of the tank without breaking steam connections or taking down a single section.

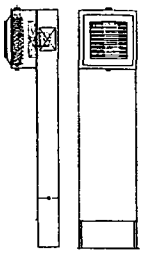
Shipped assembled in smaller sizes, and knocked down in the larger units. May be installed in horizontal or vertical position.

BAYLEY TYPE EXHAUST FAN:



An exhaust unit for handling refuse from sawmills, planing mills, cotton gins, textile mills and wood working plants, designed for high efficiency at moderate speed. Its outstanding features are the blast wheel which is built up from an accurately machined and balanced center, insuring well balanced wheel and making replacement of accidentally broken blades a simple matter.

CHINOOKFIN HEATERS:



Single Unit of the Supported Type with Air Connection from the Floor Line

Chinookfin Heaters are constructed along the lines original with the Bayley Blower Company, as described under Chinook Heating Sections.

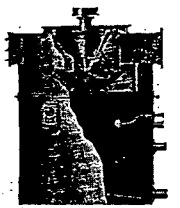
The Chinookfin unit illustrated is particularly adapted to use in offices and entrances to buildings, as well as the main portions of industrial plants. It may be connected to the outside air, and thus will ventilate as well as heat the space in which it is installed.

The heaters are sturdy, efficient, easily installed, and occupy no valuable floor or wall space. They require no special structure to carry them, and they may be attached to walls or columns, suspended from the floor above, or from the heating main, as circumstances will permit.

It is not necessary when this heater is used, to recirculate air at room temperature. Air directly from out of doors may be led to the unit, thus making it a ventilating as well as a heating unit. The entire unit is tested to a working pressure of 80 lb.

The Bayley Blower Company offer in addition to the Chinookfin described, larger sizes of industrial unit heaters. The well known B.t.u. Heater is popular in railroad roundhouses and shops. The I.C.U. Heater is also an industrial unit of somewhat lighter construction, which is adapted to use in industrial buildings of all sorts.

BAYLEY GYRO AIR AND GAS SCRUBBERS:



Bayley Scrubber Designed for Cold Gas—Special Scrubber for Hot Gas Offered for Temperatures Up to 1700 deg. fahr.

Bayley Air and Gas Scrubber is designed for cleaning boiler gas, blast furnace gas, and process gases of any kind, either hot or cold. The scrubbing medium is water, or if added humidity is undesirable, a non-volatile fluid.

Gas enters the scrubber through the scrubber wheel, which is conical in shape, and fitted with concentric rows of pins. Water at low pressure is directed upon the center of the wheel and thrown by the centrifugal force of the rapidly revolving wheel against and along the first row of pins.

The final row or ring of pins throws the water with the entrained solid matter from the gases against a splash plate, which directs it to the bottom of the scrubber. The cleansing of air or gas is thus accomplished by passing air or gas through the scrubber wheel in intimate contact with water, so that dust particles are thoroughly saturated with water and thrown off by the scrubber wheel against the splash plate, finally to settle down to the bottom of the scrubber tank.

The equipment is particularly adapted to all applications where dust may be recovered either for its value or because it forms a nuisance. Typical applications are starch mills and grain elevators.

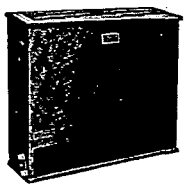
The Buckeye Blower Company

Columbus, Ohio

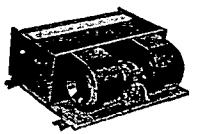
Branch Sales and Engineering Offices

ATLANTA, GA.
BALTIMORE, MD.
BOSTON, MASS.
BUFFALO, N. Y.
CHICAGO, ILL.
CLEVELAND, OHIO
DALLAS, TEXAS
DENVER, COLO.
DETROIT, MICH.
GRAND RAPIDS, MICH.
HEMPSTEAD, L.I., N. Y.
INDIANAPOLIS, IND.
KANSAS CITY, MO.
LOS ANGELES, CALIF.
MILWAUKEE, WIS.
MINNEAPOLIS, MINN.
NEW YORK CITY
NEWARK, N. J.
OKLAHOMA CITY, OKLA.
PHILADELPHIA, PA.
PITTSBURGH, PA.
PORTLAND, ORE.
SALT LAKE CITY, UTAH
SAN FRANCISCO, CALIF.
SEATTLE, WASH.
SYRACUSE, N. Y.
TORONTO, ONT.
WINDSOR, ONT.
YOUNGSTOWN, OHIO

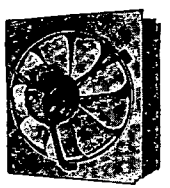
Manufacturers of BUCKEYE Heating and Ventilating and Air Conditioning Apparatus



The **Heatovent** has been developed for use in School Rooms and places where quiet running, temperature control, quick heating, and positive ventilation are requisites. This machine is equipped with the oval tube radiator which will not burst when frozen.

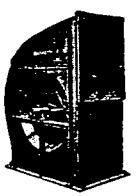


The **Thermovent** has been developed for larger installations requiring from 2000 to 10,000 c.f.m. as churches, auditoriums, garages. Horizontal type for ceiling hanging, vertical type for floor setting. Equipped with or without mixing dampers.



The **Thermofan** is a propeller fan type of unit for industrial work. Can be used for fresh air supply or recirculating jobs equipped with or without ducts to floor.

Multiblade Fans for heating, ventilating, drying, dust removal and allied uses in all sizes up to 100,000 c.f.m. and up to 6 in. static pressure.



Ozonation and humidity treatment available for all unit applications. Engineering service available in all branch offices.

Buffalo Forge Company

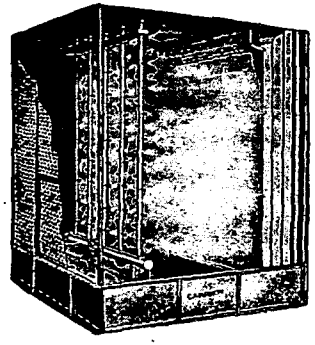
Buffalo, New York

Branches

Amarillo, Texas, Amarillo Bldg.
Boston, Mass., 10 Milk Street
Chicago, Ill., 562 W. Washington Blvd.
Cincinnati, Ohio, 604 Mercantile Library Bldg.
Cleveland, Ohio, 368 Rockefeller Bldg.
Dallas, Texas, 601 Construction Bldg.
Denver, Colo., 1621, 17th Street
Detroit, Mich., 2051 W. Lafayette Blvd.
Los Angeles, Calif., c/o Larmier & Lauer, 1824 S. Hope Street
Minneapolis, Minn., 459 N.W. National Life Bldg.
New York, N.Y., 39-41 Cortlandt Street
Philadelphia, Pa., 1302 Land Title Bldg.
Pittsburgh, Pa., 927 Union Trust Bldg.
San Francisco, Calif., 1006 Flatiron Bldg
St. Louis, Mo., 515 Chemical Bldg.
Seattle, Wash., 303 Alaska Bldg.
Washington, D.C., 418 Washington Loan & Trust Bldg.

Canadian Branch

Canadian Blower & Forge Co., Kitchener, Ontario



Carrier Air Washers

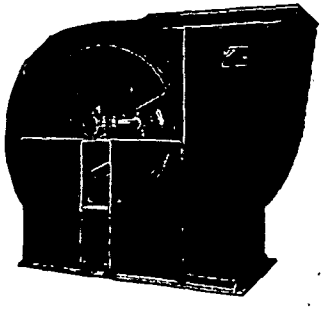
One-piece eliminators and scrubbers that are easily assembled in a few minutes and give great cleaning effect. Spray nozzles prevented from clogging by tank-width screen. Original efficiency is maintained indefinitely by a few minutes flushing out each week.

Buffalo Niagara Conoidal Fans handle large quantities of air at high efficiency under big overloads in industrial plants. Low speed and great capacity well suited to belt drive.

Buffalo Breezo-Propeller Fans are very successfully used for removing steam, odors or foul air in shops, mills and factories. Belted or direct motor driven types.



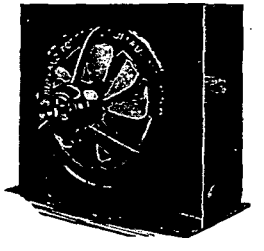
Buffalo Duplex Conoidal Fans, shown below, maintain steady pressures and good efficiency over a greater range of air demand than is possible with any other construction. Best adapted to schools, public buildings, offices, etc. Moderate speed for direct connection to motor.



Buffalo Unit Heaters

Made in four types to suit every kind of building. BREEZO-FIN Heaters (shown here), Vento Heaters, Hi-Pressure Pipe Coil Heaters, suitable for pressures up to 150 lb., and direct fired units.

Catalog 466 describes all types and sizes.



Buffalo Forge Company's Products

Carrier Air Washers
Conoidal Multiblade Fans
Disc Fans
Dust Collectors
Drying Apparatus
Forge Shop Equipment
Generator Coolers
Gas Scrubbers
Humidifiers
Induced Draft Fans
Pipe Coil Heaters
Pressure Blowers
Planing Mill Exhaust Fans
Spray Nozzles
Stoker Fans
Unit Heaters
Ventilating Sets

Complete Catalogs on any of above sent on request

Clarage Fan Company

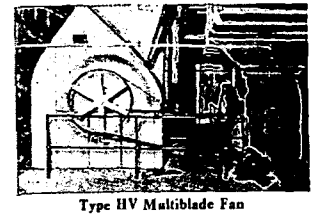
Plant and General Offices: Kalamazoo, Michigan

Sales Engineering Offices

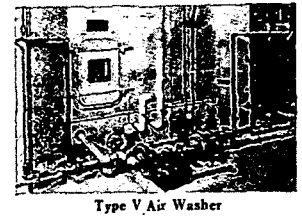
Boston, Mass.
New York City, N. Y.
Philadelphia, Pa.
Pittsburgh, Pa.
Charlotte, N. C.
Detroit, Mich.
Atlanta, Ga.
Chicago, Ill.
Minneapolis, Minn.
Cleveland, Ohio
St. Louis, Mo.
Denver, Colo.
Portland, Ore.
Los Angeles, Calif.
Omaha, Nebr.
Birmingham, Ala.
South Bend, Ind.
Indianapolis, Ind.
Seattle, Wash.
Oklahoma City, Okla.
Salt Lake City, Utah
Cincinnati, Ohio
Houston, Texas
Huntington, W. Va.
Buffalo, N. Y.
New Orleans, La.
Tacoma, Wash.

Consult Telephone Directory for Street Address of any Clarage Branch Office

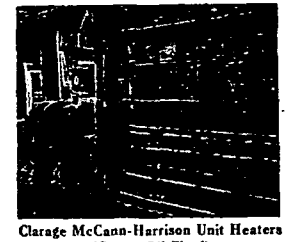
PRODUCTS—Heating, Ventilating, Air Conditioning Equipment and Allied Apparatus: HV Multiblade Fans, Air Washers, Exhaust Fans, Unit Heaters, Steam Engines, Etc.



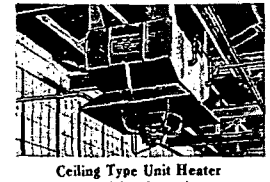
Type HV Multiblade Fan



Type V Air Washer



Clarage McCann-Harrison Unit Heaters (Gas or Oil Fired)



Ceiling Type Unit Heater (Utilizing Steam)

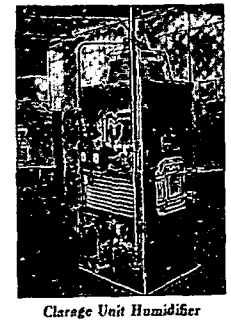
TYPE HV FAN—for heating, ventilation, air conditioning and drying. 77 per cent maximum efficiency saves 15 to 20 per cent in operating cost. Sizes from 500 to 236,000 c.f.m. Built for direct connection to motor, steam engine, etc., or belt drive.

TYPE V AIR WASHER—for all classes of air conditioning, cooling, humidifying and dehumidifying. Nozzles produce dense mist screen at low pump pressures. Exclusive design of eliminators greatly simplifies erection. Sizes to meet all requirements.

UNIT HUMIDIFIER—for industrial air conditioning, humidifying and dehumidifying. Effects substantial savings in first cost as compared with central system. Flexible; easy to install; suitable for one room or entire building.

UNIT HEATERS (Steam or Hot Water)—for industrial and garage heating. Built both ceiling and floor types, offering five times the capacity of an equal amount of direct radiation. Warm air discharged at high velocity in all horizontal directions (exclusive feature), insuring uniform temperatures and high heating efficiency. Sizes to meet all requirements.

UNIT HEATERS (Clarage McCann-Harrison, Gas or Oil Fired)—for industrial heating. Recommended where steam not available. No boiler plant or boiler equipment needed; no engineer or fireman required. Very efficient; practically no maintenance. One plant saved $50,000; smaller plant saved $3,000.



Clarage Unit Humidifier

ENGINEERING SERVICE—In every Clarage sales office are experienced engineers ready to cooperate with you. Without obligation, they welcome the opportunity to make recommendations and submit cost estimates.

CATALOGS ARE AVAILABLE ON EVERY CLARAGE PRODUCT—WRITE FOR THEM

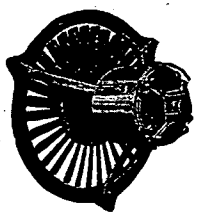
De Bothezat Impeller Co., Inc.

1922 Park Avenue, New York, N. Y.

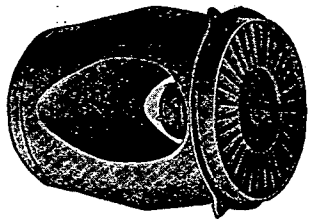
Our Fans Do Work In Ducts Against Pressure. It is prejudice to believe that Disc Fans cannot furnish static pressure with very high efficiency.

Engineering Data Concerning De Bothezat Pressure Fans

Important Notice: We guarantee our fans to have a **non-overloading power characteristic,** that is to absorb at constant revolutions practically **the same power** whatever the static pressure under which they are operating for the whole range between free delivery and no delivery.. This important property of the **De Bothezat Disc Pressure Fans insures the complete safety of their operation under any conditions to be met in practice.**

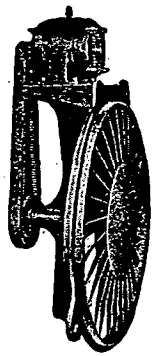


30 and 36 in. Disc Pressure Fan



BIFURCATOR

For special ventilating jobs where fumes of excessive temperature or corrosive character are to be removed.



42 and 48 in. Disc Pressure Fan

Fan Diam.	R.P.M.	H.P.	— PERFORMANCES — C.F.M. against 1/8" S.P.	C.F.M. against 1/4" S.P.	C.F.M. against 3/8" S.P.	C.F.M. against 1/2" S.P.	C.F.M. against 5/8" S.P.	C.F.M. against 3/4" S.P.	C.F.M. against 1" S.P.	C.F.M. against 1 1/4" S.P.
8"	1800	1/50	350							
	3400	1/6	700	650	600	550	500	400		
14"	850	1/20	800							
	1140	1/12	1100	900	600					
	1750	1/4	1600	1450	1300	1150	850			
18"	850	1/15	1800	900						
	1140	1/6	2500	2100	1700					
	1750	1/2	3800	3700	3500	3300	3100	2800	2000	
24"	850	1/4	4500	3800	2000					
	1140	3/4	6000	5700	5300	4900	4200	3000		
30"	600	1/3	6000	4400	2000					
	850	1	9000	8400	7600	6600	5500	3000		
	1140	2.5	12000	11500	11000	10500	10000	9500	8000	6000
36"	480	1/2	8500	6000	2000					
	690	1	12000	11000	9500	8000	6000	3500		
	850	2	15000	14500	14000	13000	12000	11000	8000	
	1140	5	20000	19500	19000	18500	18000	17500	17000	15500
42"	470	1	14000	12000	9000					
	580	2	17000	15500	14000	12000	9000			
	670	3	20000	19000	18000	16500	15000	13000		
	800	5	23500	23000	22000	21000	20000	19000	16000	11000
48"	370	1	16000	12000	7000					
	470	2	20000	18000	15000	12000				
	530	3	23000	21000	20000	18000	15000	11000		
	630	5	28000	27000	26000	24500	23000	21000	15000	

We furnish disc fans producing static pressures up to 3 inch. Higher pressures by special order.

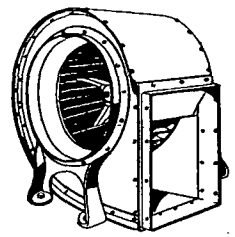
GARDEN CITY FAN CO

Manufacturers Since 1879

McCormick Building **Chicago, Ill.**

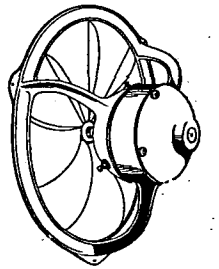
Eastern Office: 55 WEST 42ND STREET, NEW YORK

Fans, Blowers, Exhausters, Unit Heaters, Pressure Blowers, Dust Collecting, Ventilating and Drying Apparatus

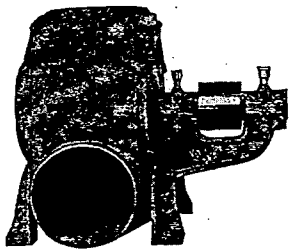


Cycloidal Multi-Blade Fan

Cycloidal Multi-Blade Fan—Sturdy construction and designed to develop an efficiency equal to any fan of this type built. Overhung wheel and overhung pulley types, suitable for Heating, Ventilating, Drying and Exhausting. Catalog No. 200 contains complete data.



Type "A" Propeller Fan



Small Exhaust Fan

Small Exhaust Fan—For exhausting refuse, dust and fumes. Made with cast-iron reversible housing. Fitted with pulleys or direct connected motors. Suitable for small jobs of all kinds.

Type "A" Propeller Fan—For exhausting foul air, steam, smoke, etc. With direct connected motors or furnished with pulleys for belt drive. Bulletin 310 contains data on various types and all sizes. Standard makes of motors used, ample in size. No overload, no heating and thus no cooling device required.

Cyclo-Fin Unit Heater—(Industrial Type)—Compact, sturdy, noiseless and fitted with heavy duty motors for severe and continuous industrial service. Heating element copper tubing with fins. Non-corrosive. Made in both suspension and floor types.

Cyclo-Fin Data

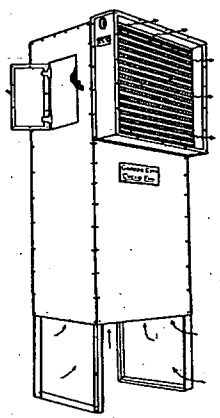
Size	C.F.M. Entering Air 60 deg.	Motor H.P.	R.P.M.	Room Temp.	B.t.u. per Hour 2 Lb. Stm.	5 Lb. Stm.	40 Lb. Stm.	Equivalent Direct Radiation 2 Lb. Stm.
16A	1350	1/8	1160	60	88,000	100,000	110,000	365 sq. ft.
18A	1900	1/5	1160	60	122,000	128,000	180,000	509 sq. ft.
24A	2900	1/3	870	60	157,000	172,000	246,000	653 sq. ft.
30CC	5200	1/2	690	60	332,000	392,000	475,000	1380 sq. ft.

Note 1.—Above capacities for single unit. Double capacities for double unit box. Triple capacities for triple unit box.

Note 2.—Table covers steam pressures of 2 lb., 5 lb. and 40 lb. steam at heaters. Any steam or hot water pressure may be used up to 50 lb. gauge pressure.

Note 3.—Sizes 18A and 24A have 2 in. supply, 1¼ in. drip. Size 30CC has 2½ in. supply and 1½ in. drip on each heater section.

Note 4.—For heating outside air use 5 lb. steam or higher pressure.



Cyclo-Fin Unit Heater

Garden City products are a combination of genuine quality and efficiency. Fifty years of experience enables us to furnish **"A Fan or Blower for Any Purpose."** A complete set of literature should be in your files.

ILG Electric Ventilating Company

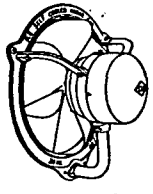
General Offices and Works

2850 N. Crawford Avenue — **Chicago, Ill.**

BALTIMORE, MD.—1403 Hearst Tower Bldg.
BIRMINGHAM—1318 Comer Bldg.
BOSTON—136 Federal Street
CHICAGO, ILL.—324 W. Monroe Street
CINCINNATI, OHIO—622 Broadway, Room 304
CLEVELAND, OHIO—1314 Schofield Bldg.
DALLAS, TEXAS—302 North Texas Bldg.
DES MOINES, IOWA—900-18th Street
DETROIT, MICH.—415 Brainard Street
HAMMOND, IND.—44 Ruth Street
HOUSTON, TEXAS—941 Electric Bldg.
INDIANAPOLIS, IND.—1004 New City Trust Bldg.
KANSAS CITY, MO.—524 Ridge Bldg.
LOS ANGELES, CALIF.—406 S. Main Street
MILWAUKEE, WIS.—326 Metropolitan Bldg.
MINNEAPOLIS, MINN.—442 Builders Exchange Bldg.
NEW HAVEN, CONN.—902 Chapel Street
NEW ORLEANS—203 Natchez Bldg., Magazine and Natchez Sts.
NEW YORK, N.Y.—15 Park Row
N.Y. EXPORT—30 Church Street, Room 420-E
PHILADELPHIA, PA.—325 Commercial Trust Bldg.
PITTSBURGH, PA.—1018 Bessemer Bldg.
ROCHESTER, N.Y.—943 Granite Bldg.
SAN FRANCISCO—215 Market Street
ST. LOUIS, MO.—1421 Syndicate Trust Bldg.
TOLEDO, OHIO—1601-22nd Street
UTICA, N.Y.—402½ Mayro Bldg.

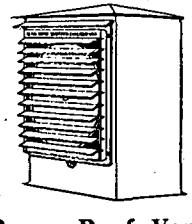
ILG Ventilation

for Offices, Stores, Restaurants, Factories, Theatres, Homes, Etc.



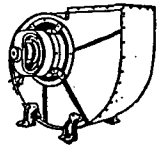
ILG Electric Ventilator

The only propellor fan made with a fully enclosed, self-cooled motor. Manufactured and carried in stock in all sizes—12 to 72 in., for any current or voltage. Guaranteed as a complete unit.



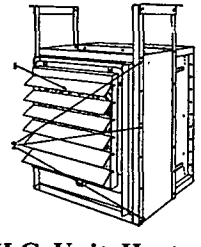
ILG Power Roof Ventilator

One ILG Power Roof Ventilator is equal to three ordinary gravity or natural ventilators. Moreover provides positive ventilation, winter or summer, in any kind of weather. Recommended for one, two and three story buildings. Sizes 12 to 72 in.



ILG Direct Connected Blowers

The motor is a built-in feature—no pedestal or support required. Shipped from factory completely assembled ready to bolt in place. Sizes ranging from 25 to 90 in.



ILG Unit Heaters

More than 13,000 in use. Recommended for spacious warehouses, factories, garages, halls, etc. A new method of blast heating using steam or hot water heat. Made for ceiling and floor installation.

Ask for any or all of these New Pictorial Bulletins

ILG Complete Catalog—200 pages
ILG Condensed Catalog—32 pages
ILG Data and Price Sheets
ILG Blower Bulletin
ILGAIR Kitchen Ventilator
ILG Power Roof Ventilator Bulletin
ILG Unit Heater Bulletin
ILG Portable Floor Fan Circular
ILG Furnace Fan

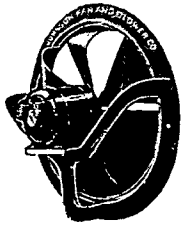
Johnson Fan and Blower Co.

1319 West Lake Street, **Chicago, Ill.**

Manufacturers of

Propeller Fans, Volume Blowers (Multivane Type), Pressure Blowers, Roof Ventilators (Motor Driven), Penthouses, Extended Shaft Fans, Low Speed Exhausters, Unit Heaters.

Offices in Principal Cities



PROPELLER FANS

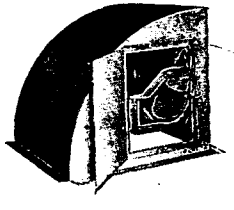
Every JOHNSON Propeller Fan is "precision" built and designed on correct ventilating and engineering practice and principles.

The outer ring, arms and motor platform are cast in one piece, thus eliminating bolts and preventing frame from getting out of alignment, during shipment or installation.

40° motors used throughout and enclosed at front to prevent grease, dirt, acid fumes and other injurious substances from injuring windings. Motors are interchangeable, so that the use of only one frame is required for direct current or alternating current.

Furnished in sizes from 12 to 72 in., for any current or voltage.

Send for catalog No. 12, containing detailed information.



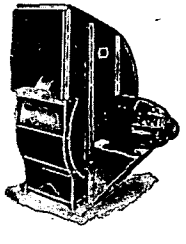
ROOF VENTILATORS (Motor Driven)

The design of JOHNSON Motor Driven Roof Ventilators, embodies a new method of construction, so that all joints are completely sealed, preventing leakage during inclement weather.

The rounded shape or graduated slope of housing greatly assists drainage in wet weather, thereby preventing injury to fan and motor.

Built in single or double compartment types. In double compartment type, the motor, being enclosed in a separate but easily accessible chamber, is protected from fumes or acids.

Write for bulletin No. 25, which contains full data and specifications.



VOLUME BLOWERS

JOHNSON Blowers are carefully constructed of the best materials. They are designed not only to be able to obtain maximum efficiency, but also, flexibility and ease of installation.

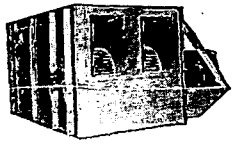
The construction admits of eight different position of discharges, both right and left hand.

Discharge velocity—in JOHNSON ratings—are based on the distance from the point of cut-off to the *nearest* point of the outer scroll. Built for any type of drive. Sizes from No. 30 are regularly equipped with Self-Aligning Ball Bearings.

Capacities range from 225 c.f.m. at ½ in. static pressure to 161,000 c.f.m. at 2 in. static pressure.

Made in wheel diameters from 6 to 90 in.

Catalog No. 25 gives complete data.



UNIT HEATERS

JOHNSON Unit Heaters cover a wide range of sizes and types, than can be obtained in any other make.

The Propeller Fan Types are built for either ceiling suspension or floor mounting. The High Velocity Blower Type Unit Heaters cover a wide range, for either ceiling suspension or floor mounting.

The method of "High Velocity" Unit Heating was originated and pioneered by Johnson.

This method adequately meets the requirements for heating interiors where ceilings are high and areas large. With this method fewer unit heaters per area are required and quicker heat in a given area is obtained.

Bulletin No. 56 contains valuable engineering data and detailed information.

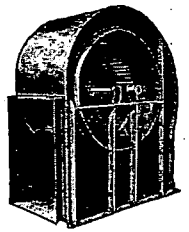
PHONE CALUMET 6650

FANS AND BLOWERS
AIR FILTERS AND WASHERS
FAN FURNACES
UNIT-HEATERS

The **NEW YORK BLOWER COMPANY**

GENERAL OFFICES
3169 SHIELDS AVE.
ARMOUR P. O. STA.
CHICAGO, ILL.

FACTORIES AT LA PORTE, IND. AND CHICAGO, ILL.

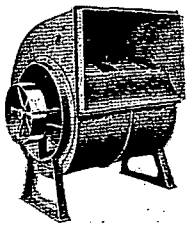


Type ME Fan

Type ME Fans cover a wide range of capacities from 100 c.f.m. to 300,000 c.f.m. Sizes up to and including No. 39 made with cast iron inlet stands and are reversible, the larger sizes made non-reversible. Fans deliver large quantities of air at high efficiency. Cone Back Multi-Blade Wheels with forward curved floats used exclusively. Fans are regularly made either with overhung pulley or overhung wheel of all hands and discharges.

We also manufacture Fans for mechanical draft, conveying systems, foundries, gas plants and stokers.

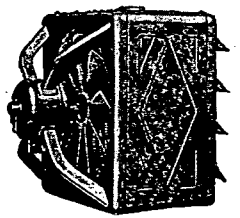
Write for Catalog No. 100 containing complete data.



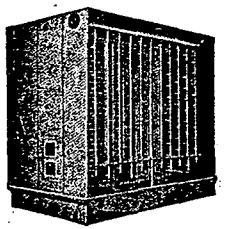
Comet Unit-Heaters

For use with steam. Made in two sizes, as shown in table. A Heavy Duty Disc Fan direct connected to motor drives air over heating coils. Unit-Heaters using pipe coil and vento made in convenient sizes.

Write for Bulletin 85 which gives complete data including B.t.u. capacities under various conditions.



Size Heater	Cu.Ft. per Min.	Cu. Ft. per Hour	Motor		Dimensions			E.D.R.	Wght. Complete
			R.P.M.	H.P.	Height	Width	Depth		
8	800	48,000	1050	1/20	15	15	8	240	80
18	1800	108,000	850	1/10	23	23	12½	540	200
24	2400	144,000	1160	1/6	23	23	12½	720	200
60	6000	360,000	680	1/2	34	34	15¼	1800	550



Air-Washers and Humidifiers

Peerless Air-Washers and Humidifiers, Type "D" and "E," with capacities ranging from 3600 c.f.m. to 112,000 c.f.m. of value for washing, drying, humidifying and cooling. Also for special processes as paper, textiles, tobacco, glue, leather and wood.

Write for more detailed descriptive literature.

Atlanta, Ga.
Birmingham, Ala.
Boston, Mass.
Buffalo, N. Y.
Camden, N. J.
Charlotte, N. C.
Chicago, Ill.
Cincinnati, O.
Cleveland, O.
Dallas, Tex.
Denver, Colo.
Detroit, Mich.
Hartford, Conn.
Indianapolis, Ind.

B. F. Sturtevant Co.

Hyde Park, Boston, Mass.

Sturtevant

PLANTS LOCATED IN

CAMDEN, N. J. HYDE PARK, MASS. FRAMINGHAM, MASS.
STURTEVANT, WIS. GALT, ONT. BERKELEY, CALIF.

Kansas City, Mo.
Los Angeles, Cal.
Milwaukee, Wis.
Minneapolis, Minn.
Montreal, P. Q.
New York, N. Y.
Omaha, Neb.
Pittsburgh, Pa.
Portland, Ore.
Rochester, N. Y.
St. Louis, Mo.
San Francisco, Cal.
Seattle, Wash.
Toronto, Ont.
Washington, D. C.

STURTEVANT PRODUCTS

The wide application of Sturtevant Products can hardly be discussed here; so for the convenience of the architect, engineer and contractor the publications listed below have been prepared to aid in the selection of proper equipment for industrial, public, and private buildings of all types and sizes. We will gladly send you any of these publications on request.

ENGINEERING SERVICE

Each office, address shown above, maintains a force of trained engineers who are always ready to analyze the conditions of any prospective installation and make recommendations for suitable equipment.

CATALOGS

Heating and Ventilating Equipment

No. 227 Heating and Ventilating Layouts.
230 Heaters.
271 Multivane Fans.
357 Disc and Propeller Fans.
283 Autoforce Ventilators.
290 Silentvane Fans.
295 Air Washers.
327 Portable Disc Fan.
332 Ventilating Sets.
333 Silentvane Fan Performance Tables.
337 Monogram Fans.
339 Unit Heater.
340 Ventilating Fans.
341 Hot Job Fans.
361 Unit Ventilators.
363 Tempervane Heaters
364 Tempervane Cabinet Heater
No. 345 Carbon Monoxide Asphyxiation and Its Prevention.
349 Coal Burning Blowers
1011 Heating and Ventilating Picture Book, Factory Section.
1012 Heating and Ventilating Picture Book, School Section.
1013 Heating and Ventilating Picture Book, Public Building Section.
1014 Heating and Ventilating Pictur Book, National, State and County Building Section.
1016 Heating and Ventilating Watervliet, Shops D. & H. Railroad.

Power Plant Equipment

No. 236 Forced Draft Apparatus.
275 Gear Transmissions.
288 Forced and Induced Draft with Mechanical Stokers.
309 Turbo-Transmissions.
311 Steam Turbines, Type 12.
330 Turbovane Fans, Design 4 and 5.
331 Air Economizers.
334 Lead Coated Extended Fin Economizers.
346 Propeller Type Forced Draft Fan.
347 Tubular Air Heater.
348 Turbovane I. D. Fan.
349 Coal Burning Blowers.
360 Discussion of Fans for Mechanical Draft.

Vacuum Cleaning Equipment

No. 320 Stationary Vacuum Cleaners.
324 Vacuum Cleaners, Heavy Duty.
342 Vacuum Cleaner, Furnace and Boiler Cleaning.

L. J. Wing Mfg. Co.

Branch Offices in Principal Cities — 59 Seventh Avenue, **New York** — PHONE: CHELSEA 0027-0030 — **Factory: NEWARK, N. J.**

Manufacturers of Wing Featherweight Unit Heaters, Wing Turbine and Motor Driven Blowers, Wing-Scruplex Fans, Exhausters, Fog Eliminators

Wing Featherweight Unit Heaters

The Wing Featherweight Unit Heater, expressly designed for overhead installation, makes available for any industrial building a heating system that leaves all floor and wall space absolutely unobstructed. The success of this system has been proven by the satisfactory operation of several hundred units in industrial buildings of every kind and description.

The installation of Wing Featherweight Unit Heaters is extremely simple, due to their light weight and small dimensions. For instance, a unit equal in heating effect to 12,000 sq. ft. of direct radiation, weighs only 332 lbs. A few advantages attending the installation of Wing Featherweight Unit Heaters may be briefly summarized as follows:

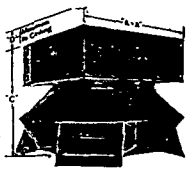
The heated air from the units, located at or near the ceiling or roof, is delivered directly downward toward the floor. heating the working level first. Chilled areas, caused by opening of doors, are almost instantly brought back to normal temperature by this downward method of heating.

Since the air recirculated by the heaters is taken from the upper spaces and delivered to the lower levels, it is evident that an active circulation of air from the ceiling to the floor is continuously maintained and that, therefore, excessive heat is not allowed to accumulate in the upper spaces, as is the case with any system of heating that allows the heat to rise to the ceiling immediately.

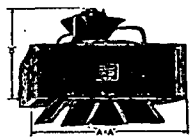
The steam and return lines are carried entirely overhead, eliminating costly pipe trenches which are necessary when radiation is placed at or near the floor.

All vertical type heaters are furnished with ball bearing motors that do not require attention more than once a heating season.

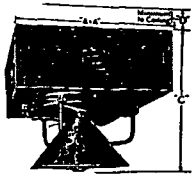
See inside page for dimension table on Wing Heaters



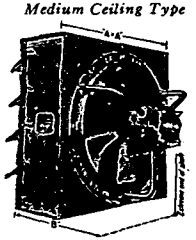
Low Ceiling Type



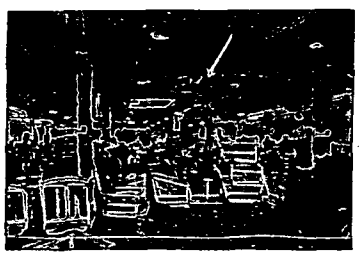
High Ceiling Type



Medium Ceiling Type



Horisontal Type



Low Ceiling Heater in Furniture Factory



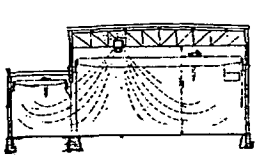
High Ceiling Heaters in Car Repair Shop

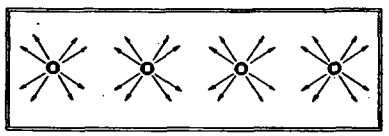
Methods of Installation



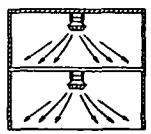
Five Wing Heaters in this Shop

The drawings below show typical high ceiling and low ceiling installations, together with a plan view illustrating the general distribution and diffusion of the heated air from the unit heaters. The first illustration shows the high ceiling type heater installed 30 or more feet from the floor, above the travelling crane, the heater arranged so that the left lower portion of the building is also heated. The third illustration shows a typical multi-story building heated with Wing low-ceiling type Unit heaters. The column of heated air leaves the heater with sufficient velocity to strike the floor with considerable force from this point, but by the aid of adjustable diffusers the column is divided and directed so that no objectionable velocity is felt at the head line. The best and most economical installation of Wing Featherweight Unit Heaters is when they are placed close to the roof or ceiling.





PLAN



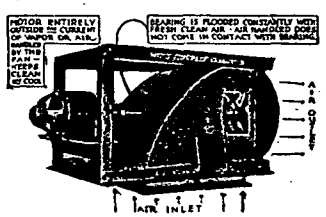
Condensed Table of Engineering Data—Wing Featherweight Unit Heaters

Unit Size	"A x A" Inches	B Inches	C Inches	D Inches	Air C.f.m.	Motor Hp.	Temperature		B.t.u. per Hour Available	Approximate Shipping Weight Lb.
							Room	Leaving		
13-4-12	19¼	25	25	6	1150	⅛	60	110	69,500	185
17-3-12	22¾	27½	27½	6	1950	⅛	60	110	96,900	212
22-3-12	27¾	27¼	27¼	6	3200	⅛	60	112	162,000	270
22-4-12	27¾	27¼	27¼	6	2800	⅛	60	122	169,000	280
22-5-12	27¾	27¼	27¼	6	2600	⅛	60	133	180,000	288
25-4-12	32¾	28¾	28¾	7	4800	½	60	122	289,500	320
25-5-12	32¾	28¾	28¾	7	4500	½	60	133	311,400	332
30-4-85	40⅛	37¼	37¼	8	6900	1	60	122	416,000	360
30-5-85	40⅛	37¼	37¼	8	6500	1	60	133	450,000	365
36-4-85	46⅛	39⅝	39⅝	8	9600	2	60	122	579,000	504
36-5-85	46⅛	39⅝	39⅝	8	9000	2	60	133	623,000	528

Space does not permit complete table for other room temperatures but this data will be gladly furnished on application.

Wing Fog Eliminators

Wing Fog Eliminators supply tempered fresh air to completely de-fog dyehouses, bottling, preserving and pasteurizing plants, paper mills, and in general any building or room where steam, fog or fumes are liberated in manufacturing processes.



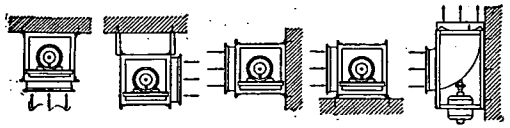
Wing-Scruplex Exhauster

Wing-Scruplex Exhausters

Wing Scruplex Exhausters consist of the highly efficient "screw propeller" fan encased in appropriate manner with a motor on the outside where it is clean, cool and easy of access. They are used in duct work where the resistance is low and being designed in the form of an elbow fit snugly in any line. The diagrams at top of next page show the methods of installation.

(continued on next page)

Proper Selection of Exhausters



Bolted directly to Ceiling | *Hung from Ceiling* | *Bolted directly to Side Wall* | *Bolted to Floor or Foundation* | *Vertical Bolted to Side Wall*

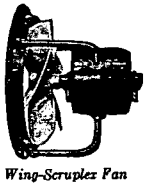
Where particularly quiet operation is desired, as in offices, residences, hospital wards, etc., use lowest speeds in all sizes in the table below. For toilet rooms, laboratories, motion picture booths, stock-rooms, etc., use any speed in sizes 1 and 2; low and medium speeds in all other sizes. In industrial plants, engine-rooms, workshops, etc., use any speeds.

Capacities of Wing-Scruplex Exhausters up to 0.5" static. Complete data on request.

Size	Inlet Sq. In.	Outlet Round In.	Speed R.p.m.	Free Air		.15 in.		.25 in.		.40 in.		.50 in.	
				C.f.m.	Hp.	C.f.m.	Hp.	C.f.m.	Hp.	C.f.m.	Hp.	C.f.m.	Hp.
1-A	10	10½	1750	850	0.052	630	0.054	330	0.060	.....	.....	.....	.....
2-A	13½	14⅛	1150	1440	0.060	950	0.069	395	0.090	.....	.....	.....	.....
2-B	13½	14⅛	1750	2050	0.195	1895	0.208	1695	0.216	1155	0.248	750	0.285
3-S	16¾	17⅝	850	2130	0.090	1250	0.110	845	0.125	.....	.....	.....	.....
3-A	16¾	17⅝	1150	2700	0.180	2150	0.195	1550	0.221	650	0.292	.....	.....
3-C	16¾	17⅝	1750	4000	0.600	3720	0.635	3510	0.655	3150	0.700	2810	0.720
4-S	21	21¾	850	2850	0.100	2200	0.11	1610	0.12	.....	.....	.....	.....
4-A	21	21¾	1150	3575	0.170	3150	0.200	2775	0.220	1950	0.245	1550	0.280
4-C	21	21¾	1750	5400	0.540	5160	0.600	4990	0.650	4670	0.710	4440	0.750
5-A	25	25	1150	5200	0.330	4720	0.380	4250	0.440	3300	0.530	2610	0.600
5-B	25	25	1750	8000	1.330	7740	1.360	7540	1.400	7175	1.480	6900	1.540
6-A	30	30	600	5500	0.210	3725	0.250	2375	0.330	1400	0.49	.....	.....
6-B	30	30	850	7400	0.550	6280	0.600	5450	0.740	4000	0.830	3400	0.960
6-C	30	30	1150	10250	1.500	9520	1.550	8950	1.570	8000	1.620	7340	1.760

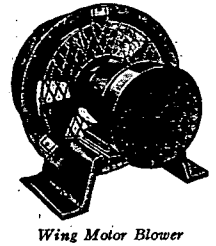
Wing-Scruplex Fans

Wing-Scruplex Fans are built in the following sizes: 10 in., 13 in., 17 in., 22 in., 25 in., 30 in., 36 in., 42 in., 54 in., and 60 in. Capacities from 950 c.f.m. to 33,000 c.f.m. Up to 25 in. diameter, propellers are made of cast aluminum alloy while the larger sizes are of pressed steel.



Wing-Scruplex Fan

Wing Buckwheat Burning Blowers



Wing Motor Blower

Wing Motor-driven Blowers are installed in heating boilers so that low cost Buckwheat coal can be burned with great savings in fuel bills and with better heating results. They are also used in industrial plants where motor drive is preferred to turbine drive.

The Wing E M Blower is a simple compact unit of motor, fan, and casing, of the same general design as the Wing Turbine Blower, the first individual forced draft fan blower ever built. Wing units are either set directly in the boiler brick base or are equipped with mounting feet or base and connected to the ashpit by a short duct in the case of cast iron boilers.

Motors are fully enclosed and dustproof. Because of this feature they stand up for years in the dusty atmosphere of boiler rooms without repair. Another feature is variable speed control; this permits of regulation without the use of dampers and saves power.

Booklet 46 describes Wing motor-driven units.

Information also available on Wing turbine-driven units.



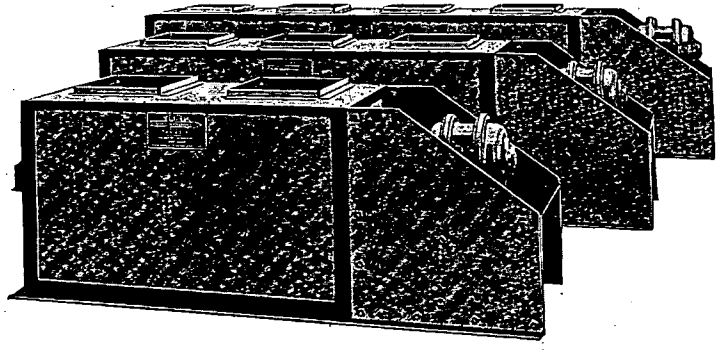
The Wing Blower in foreground supplies forced draft to hot water supply heater; while blower in background serves two return tubular heating boilers

York Heating and Ventilating Corp.

York Bldg., 16th and Sansom Streets, **Philadelphia**

Branch Offices and Representatives in All Principal Cities

York Heat-Diffusing Units for Heating Factories, Shops, Garages, Etc.



YORK UNIT FANS FOR SUPPLY OR EXHAUST VENTILATION

Advantages:

Easier to install. Fans and motor are a unit, needing no separate support.

No platform required—may be suspended by rods.

Both fan and motor are equipped with ball bearings, requiring lubrication only twice a year.

Takes rectangular duct.

Can be installed in a straight run of duct work without an offset. Due to the multiple fan assembly, the width and depth of the unit are less than for any other fan of the same capacity.

Vertical or Horizontal:

The 400 series units are designed for vertical installation. The 600 series units are designed for horizontal installation. The 600 series have the same ratings as the 400 series. Example: the 601-F has the same rating as the 401-F.

RATINGS

1750 R. P. M.—C. F. M. and H. P. at 70°F.

Size Unit	Free Delivery		¼" S. P.		½" S. P.		¾" S. P.		1" S. P.		1¼" S. P.		1½" S. P.	
	C.F.M.	H.P.	C.F.M.	H.P.	C.F.M.	H.P.	C.F.M.	H.P.	C.F.M.	H.P.	C.F.M.	H.P.	C.F.M.	H.P.
401F	2030	0.54	1825	0.52	1615	0.50	1400	0.48	1165	0.45	910	0.43	640	0.40
402F	4060	0.94	3650	0.90	3230	0.87	2800	0.83	2330	0.79	1820	0.75	1280	0.70
403F	6150	1.40	5505	1.34	4860	1.29	4215	1.23	3510	1.18	2730	1.12	1920	1.04
404F	8200	1.85	7340	1.78	6480	1.70	5620	1.63	4680	1.56	3640	1.48	2560	1.37

1160 R. P. M.—C. F. M. and H. P. at 70°F.

Size Unit	Free Delivery		⅛" S. P.		¼" S. P.		⅜" S. P.		½" S. P.		⅝" S. P.		¾" S. P.		1" S.P.		1¼" S.P.		1½" S.P.	
	C.F.M.	H.P.	C.F.M.	H.P.	C.F.M.	H.P.	C.F.M.	H.P.	C.F.M.	H.P.	C.F.M.	H.P.	C.F.M.	H.P.	C.F.M.	H.P.	C.F.M.	H.P.	C.F.M.	H.P.
401F	1360	0.20	1215	0.20	1065	0.19	905	0.18	715	0.18	495	0.17	.....	.....	.....	.....	.....	.....	.....	.....
402F	2720	0.35	2430	0.34	2130	0.32	1810	0.31	1430	0.30	990	0.28	.....	.....	.....	.....	.....	.....	.....	.....
403F	4110	0.475	3675	0.46	3210	0.45	2730	0.43	2145	0.41	1485	0.39	.....	.....	.....	.....	.....	.....	.....	.....
404F	5480	0.595	4900	0.58	4280	0.55	3640	0.53	2860	0.50	1980	0.48	.....	.....	.....	.....	.....	.....	.....	.....
482F	11200	2.37	10700	2.32	10160	2.26	9600	2.20	9050	2.15	8450	2.10	7750	2.05	6600	1.95	5200	1.86	3650	1.77
483F	15230	3.20	14550	3.15	13830	3.07	13100	3.01	12330	2.94	11570	2.88	10750	2.82	9040	2.70	7220	2.62	5250	2.50

870 R. P. M.—C. F. M. and H. P. at 70°F.

Size Unit	Free Delivery		⅛" S. P.		¼" S. P.		⅜" S. P.		½" S. P.		¾" S. P.		1" S. P.	
	C.F.M.	H.P.	C.F.M.	H.P.	C.F.M.	H.P.	C.F.M.	H.P.	C.F.M.	H.P.	C.F.M.	H.P.	C.F.M.	H.P.
482F	8400	1.10	7780	1.07	7100	1.05	6400	1.02	5680	1.00	4080	0.95	2180	0.88
483F	11400	1.43	10570	1.35	9650	1.32	8730	1.28	7750	1.25	5650	1.23	3100	1.16

S. P. is Static Pressure available for use external to UNIT itself.

Armstrong Cork & Insulation Company

Pittsburgh, Pa.

Offices

Albany	Chicago	Houston, Tex.	New York
Atlanta	Cincinnati	Jacksonville, Fla.	Rochester
Birmingham	Cleveland	Kansas City	St. Louis
Boston	Dallas	Memphis	Montreal, Que., Can.
Buffalo	Denver	Milwaukee	Toronto 2, Ont., Can.
Charlotte, N.C.	Detroit	Minneapolis	

Armstrong Cork Company, Ltd., London, England

Representatives

Baltimore	John R. Livezey	San Francisco	Van Fleet-Freear Co.
Los Angeles	Gay Engineering Corp.	Seattle	D. E. Fryer & Co.
New Orleans	H. T. Steffee	Spokane	D. E. Fryer & Co.
Philadelphia	John R. Livezey	Tacoma	D. E. Fryer & Co.
Portland	Gillen-Cole Co.	Washington	John R. Livezey

Detailed information, samples, and descriptive literature may be obtained on application to any of these offices or representatives.

Armstrong's Cork Machinery Isolation is a special grade of corkboard for absorbing noise and vibration under moving machines such as fans, motors, etc.

The natural resilience of cork and the fact that it does not "set" under pressure nor harden with age make it especially suitable for this use.

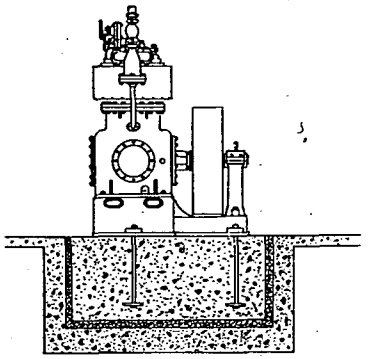
Another advantage of Armstrong's Cork Machinery Isolation is that, being a manufactured product, its density can be varied to suit different conditions. Armstrong's is made in six grades, or densities, from 1.1 to 1.66 lb. per board foot. By adapting the grade to weight and type of machine, much better results are obtained than by using a single grade for all installations.

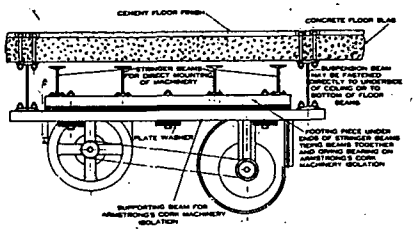
Armstrong's Cork Machinery Isolation is made in boards 12 by 36 by 1, 1½, 2, 3, 4, 5 and 6 in. thick. The standard boards may be sawed or cut into the desired shape or size as readily as lumber, and where large pads are required, they can be made in sections and cemented together.

The density and thickness to be used cannot be determined accurately until such factors as the weight, speed and character of the machine to be isolated are known. Generally speaking, the grades which should be used under different classes of machines are as follows:

Small fans, motors, generators, etc.	1.10 to 1.20
Large fans, medium size motors and generators, light machines and machine tools, etc.	1.25 to 1.33
Heavy motors and generators, large machines and machine tools, engines, etc.	1.50 to 1.66

Two methods of installing Armstrong's Cork Machinery Isolation are usually followed. In the first, the foundation pits are lined with Armstrong's Cork Machinery Isolation on the bottom and sides. The foundation proper is then poured in on top of the cork. In the second, the cork is placed between the base of the machine and the foundation, floor or ceiling, to which it is fastened. See figures below.





Langenberg Manufacturing Co.

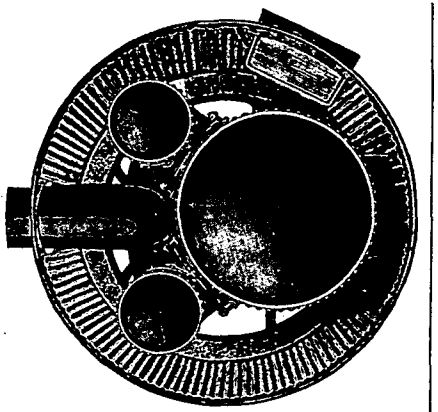
4549 No. Euclid Ave. :-: St. Louis, Mo.

HEATING FRONT RANK SYSTEMS
TRADE NAME REGISTERED

OFFICIAL MEASUREMENTS AND RATING MADE BY
NATIONAL WARM AIR HEATING AND VENTILATING ASS'N
FRONT RANK FURNACE

NUMBER	515	
GRATE AREA	388	SQ. IN.
HEATING SURFACE	8490	SQ. IN.
RATING	705	SQ. IN.

4TH EDITION STANDARD CODE



FRONT RANK furnace is riveted gas tight and dust proof and even when abused remains so; is smooth, offering slight resistance to the air. Where damp soot can lie during the non-firing period—bottom of radiator; connections between combustion dome and radiator; feed and ash pit pouches—these parts are of grey iron on FRONT RANK. The steel parts are Copper-Bearing Steel.

FRONT RANK has great radiating surface in proportion to grate area; radiator is supported by brackets and does not add weight to combustion dome; so designed that soot, etc. drops to bottom where it is easily cleaned out; is lined with refractory material which becoming incandescent ignites solid fuel near edge of grate.

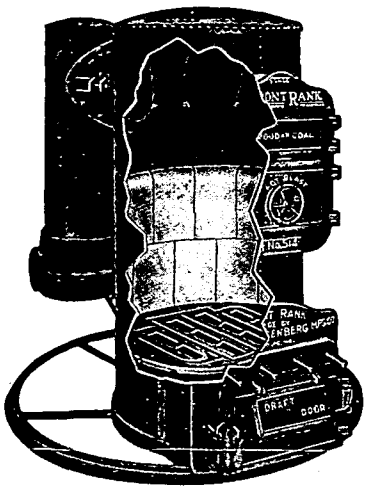
FRONT RANK HEATING SYSTEMS consist of this furnace installed according to the Standard Code. Authorized Dealers are located near you.

No. of Furnace*	Over-all Height In.	Grate Area Sq. In.	Ratio: Heating Surface Grate Area	Rating Sq. In.	Size Feed Door Sq. In.	Size Ash Door Sq. In.
381	68	177	36.1	350	10 x12	8¼x11½
455	72	258	28.6	529	8¾x12½	10 x15½
515	73	388	21.9	705	8¾x12½	10 x15¼
575	75	471	21.8	853	8¾x12½	12¼x14
635	75	578	20.0	1015	8¾x12½	12¼x14
665	89	578	24.0	1093	8¾x12½	12¼x14

*First two figures of number are diameter of casing.

The above data in connection with the Standard Code, published as a part of the Chapter on Gravity Warm Air Heating, will enable the Architect, Engineer or Contractor to specify the correct size FRONT RANK furnace for any project.

Any FRONT RANK furnace installed by an authorized dealer according to the Standard Code is guaranteed to maintain an average temperature of 70 deg. in zero weather.



Ellison Draft Gage Company

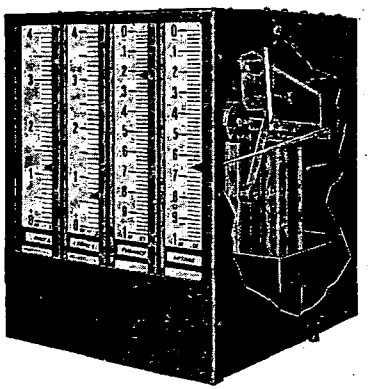
214 West Kinzie Street :-: **Chicago, Ill.**

Products:

Ellison Draft Gages and Steam Calorimeters. Designed by Lewis M. Ellison and manufactured by Ellison Draft Gage Co.

Ellison Pointer Draft Gages:

STRAIGHT-LINE VERTICAL: *This improved pointer draft gage, converting an arc into a straight line, is of remarkable accuracy and repeats precisely. It is of unusual substantial construction and is made in 1 to 12 readings, wall or panel type, with color code system of drafts. It has a powerful bell of 10 cu. in. displacement. The fulcrum knife*



edges are of hardened steel, ¼ in. long. The bells have a common pan, with drain, and the liquid used is mineral oil. The pan is filled thru a large tube in the side or back, combining a filler and liquid level indicator.

The scales are 10 in. long, of uniform spacing, and are illuminated from the back with a standard 15 watt bulb, one for eight pointers.

Dial Type: Of the same excellent construction and accuracy as the straight-line type, having the same filler, knife edges, beam and bell, using the same liquid.

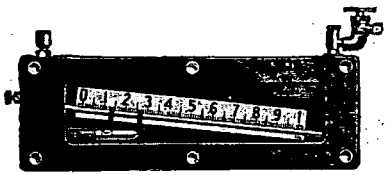
It is made in two sizes, 0 to 5 in. and 0 to 8 in. range or in mm. graduations, minus or plus, and in one and two-pointer gages. The two-pointer is intended for furnace and uptake or pit pressure and furnace.



The scale is of white opaque celluloid, 10 in. long, with large figures, readings visable across the boiler room.

Ellison Tube Draft Gages:

The famous Ellison Inclined Tube Gage, the recognized standard of accuracy in draft gages, was introduced in 1896. Water having a variable movement, a mineral oil is used. Except the inclined-vertical type, all the gages have sliding scales for setting zero, requiring no frequent refilling. The stationary gages have white enameled scales, and the open type inclined gages, white metal scales, with micrometer leveler.

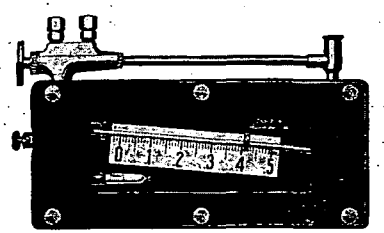


INCLINED DRAFT GAGE: *Made in .3 in. range for domestic furnaces and in ½, 1, 2, 3, 4, 5, 6 and 7½ in. range, and in mm., for power boilers, suction, pressure or differential.*

COMBINATION INCLINED DRAFT GAGE: *By turning the handle, this gage reads furnace, flue or differential draft in 1 and 1½ in. range, and in mm.*

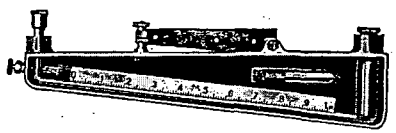
COMPOUND INCLINED DRAFT GAGE: *This gage reads furnace draft to left, flue draft or differential to right of zero in in. and mm scales.*

MULTI-TUBE INCLINED DRAFT GAGE: *Made in 2, 3 and 4 tubes in 1 to 7½ in. range, and in mm., suction, pressure or differential.*

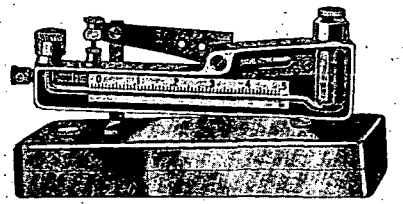


INCLINED AIR FILTER GAGE: *Indicates differential thru air filters and the time for cleaning by setting the pointer at the highest reading that will clean the air properly. Made in ½ and 1 in. range, and in mm.*

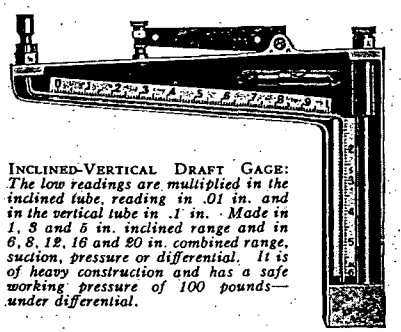
This differential system furnished for any of the included gages for Pilot tubes and other differential readings, which prevents the liquid blowing out with static pressures in excess of the scale range.



INCLINED DRAFT GAGE—OPEN TYPE: *For technical institutions and power plant testing. With sliding scale and micrometer leveler. Made in 1, 1½, 2, 3 and 5 in. range, and in mm., suction, pressure or differential.*

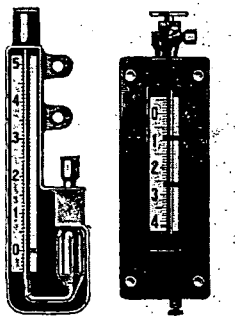


PORTABLE INCLINED DRAFT GAGE: *For traveling engineers, light and compact, with leveling stand. Made in ½, 1, 1½ and 2 in. range. Also two-tube in ½ and 1 in. and in ½ and 1½ in. ranges. All gages with or without attachments and pressed aluminum carrying cases.*



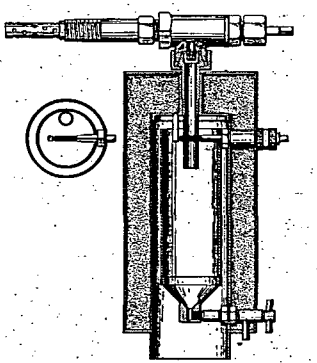
INCLINED-VERTICAL DRAFT GAGE: *The low readings are multiplied in the inclined tube, reading in .01 in. and in the vertical tube in .1 in. Made in 1, 3 and 5 in. inclined range and in 6, 8, 12, 16 and 20 in. combined range, suction, pressure or differential. It is of heavy construction and has a safe working pressure of 100 pounds—under differential.*

VERTICAL DRAFT GAGES: *The open type is for portable use and is made in 5 and 10 in. range, and in oz. Also in 4, 7 and 12 in. range in the sliding scale type. The single tube cover type is for stationary use and is made in 4, 7, 12 and 20 in. range, and in cm. and oz. In multi-tube it is made in 2 tubes 7 in., 3 to 6 tubes 7, 10 and 20 in., 8 to 12 tubes 7 and 10 in. range.*



Ellison U Path Steam Calorimeter:

In this recently improved steam calorimeter, a remarkable performance of 2 degrees within the theoretical temperature is obtained.



Steam enters and escapes at the top of the steam chamber, forming a U path. Momentary excess moisture is separated and re-evaporated by the superheated steam, lowering the temperature on the superheat thermometer in direct proportion. This cycle forms a throttling, separating and re-evaporating calorimeter in a single steam chamber, which is steam jacketed by the down-flow escaping steam. The jacket steam is protected against chilling by a 1 in. insulating jacket on the sides and 1½ in. on the top of the jacket, which is filled with lamp black and encased by a bright nickel plated casing.

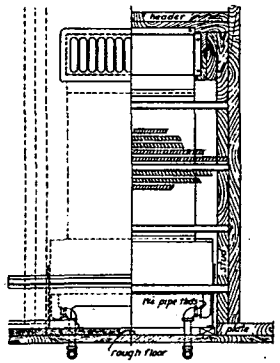
Circulair Heat, Inc.

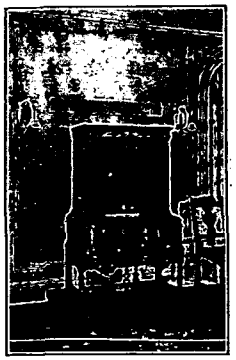
215 Central Avenue
Louisville, Ky.

50 Church Street
New York

1916 Builders Bldg.
Chicago







Circulair is a new method of heating for use with hot water, steam or vapor systems which economically produces a uniform, comfortable, healthful temperature by scientifically using induced circulation of air.

The **Circulair** Heat Unit uses only a fraction of the space required normally for room heating equipment and consists of a carefully designed seamless copper tube on which are pressed die-stamped fins evenly spaced. It is mounted in a heavy metal protective casing.

Circulair Units are available in various widths and lengths and may be concealed in walls, under windows or in partition walls with high stacks. The higher the stack, within practical limits, the greater the capacity of the heater. Also furnished in cabinets.

The concealed **Circulair** heater is usually plastered over but removable plaster wall panel may be supplied to provide ready acess to heater, piping and valve. This panel is plastered on the job when the wall is plastered and is invisible when the wall is finished.

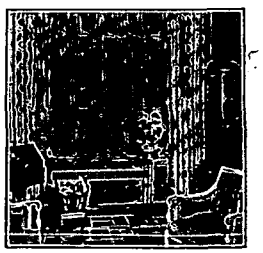
Circulair Heat Units are rated in equivalent square feet of cast iron radiation. All ratings are based on 240 B.t.u. per square foot and were established by actual condensation tests. Capacities depend upon (1) Type of Heater, (2) Length of Heater and (3) Height of stack.

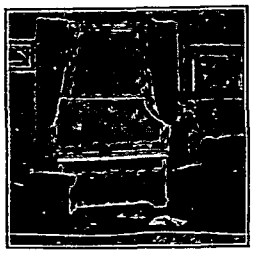
The type of heater to be used is determined by the thickness of wall or partition in which it is to be installed. The No. 4 heater is designed for use in walls between 2 x 4 in. studding; the No. 6 between 2 x 6 in. studding; the No. 8 between 2 x 8 in. studding and the No. 16 in window seats, under floors and in walls permitting a recess 16 in. deep. The **Circulair** Cabinet is furnished in two types: Standard and Double Capacity. The No. 8 Heater is used in the Standard Cabinet, and the No. 16 Heater in the Double Capacity Cabinet.

The Standard and Double Capacity Cabinets are made in three heights, 20, 26 and 38 inches, and seven lengths of 19, 25, 31, 37, 43, 49 and 55 inches, a total of 42 sizes with a wide range of capacities to meet any heating requirement. All Standard Cabinets are 9 inches deep and Double Capacity 17 inches deep. For a given size the Double Capacity Cabinet has twice the capacity of the Standard Cabinet.

All Cabinets are finished in priming coat unless otherwise specified. Special mahogany, walnut or oak wood grain finish can be furnished at an additional charge.

The concealed types are readily adapted to any decorative scheme, have the advantage of permitting full use of floor space and at the





same time secure a uniform distribution of heat throughout the zone occupancy so that the temperature variation between floor and ceiling is only 5 deg.

Circulair in the cabinet types affords all of the advantages of this improved method of heating and fits in nicely with any decorative treatment desired and in the use of this scientific method of heating the occupants of a building reap the benefit of comfort, health, convenience and economy.

Engineering data sheets with piping details are available to architects, engineers and heating contractors. Examples of capacity tables for several styles of heaters are shown. Additional data sheets for A. I. A. file 30c4 cover the complete line of **Circulair** Convection Heaters.

CAPACITY TABLES FOR CIRCULAIR HEATERS

No. 4 CONCEALED TYPE
For installation between 2 x 4 Studs

Overall Height	Length of Heater 12″	18″	24″	30″	36″	42″	48″
	Overall Length between End Trappings 18″	24″	30″	36″	42″	48″	54″
20″	8.0	12.0	16.0	20.0	24.0	28.0	32.0
25″	9.3	14.0	18.7	23.3	28.0	32.7	37.3
30″	10.7	16.0	21.1	26.7	32.0	37.4	42.3
35″	12.0	18.0	24.0	30.0	36.0	42.0	48.0
40″	13.1	19.6	26.2	32.7	39.2	45.8	52.4
45″	14.2	21.2	28.4	35.5	42.5	49.7	56.8
50″	15.2	22.8	30.1	38.0	45.5	53.2	60.8
55″	15.9	23.8	31.8	39.7	47.7	55.6	63.6
60″	16.8	25.2	33.0	42.0	50.5	58.7	66.0
65″	17.4	26.0	34.4	43.3	52.1	60.6	68.8
70″	17.9	26.8	35.8	44.7	53.7	62.6	71.6
75″	18.3	27.4	36.6	45.7	55.0	64.0	73.2
80″	18.7	28.0	37.4	46.7	56.2	65.4	74.8
85″	19.0	28.5	38.0	47.5	57.0	66.5	76.0

No. 6 CONCEALED TYPE
For installation between 2 x 6 Studs

Overall Height	Length of Heater 12″	18″	24″	30″	36″	42″	48″
	Overall Length between End Trappings 18″	24″	30″	36″	42″	48″	54″
20″	10.0	15.0	20.0	25.0	30.0	35.0	40.0
25″	11.1	16.6	22.2	27.7	33.2	38.8	44.3
30″	12.6	18.9	25.3	31.6	37.9	44.2	50.6
35″	14.1	21.1	28.1	35.1	42.1	49.1	56.2
40″	15.3	23.0	30.6	38.3	45.9	53.6	61.3
45″	16.5	24.7	32.9	41.2	49.4	57.6	65.8
50″	17.6	26.3	35.1	43.9	52.7	61.5	70.2
55″	18.5	27.7	37.0	46.2	55.4	64.7	73.9
60″	19.3	29.0	38.7	48.4	58.0	67.7	77.4
65″	20.1	30.1	40.1	50.2	60.2	70.2	80.2
70″	20.8	31.3	41.7	52.1	62.5	72.9	83.4
75″	21.5	32.3	43.0	53.8	64.5	75.3	86.0
80″	22.1	33.1	44.1	55.2	66.2	77.2	88.2
85″	22.5	33.7	44.9	56.2	67.4	78.7	89.9

No. 8 CONCEALED TYPE
For installation between 2 x 8 Studs

Overall Height	Length of Heater 12″	18″	24″	30″	36″	42″	48″
	Overall Length between End Trappings 18″	24″	30″	36″	42″	48″	54″
20″	12.0	18.0	24.0	30.0	36.0	42.0	48.0
25″	14.2	21.3	28.4	35.5	42.5	49.7	56.8
30″	15.8	23.7	31.6	39.5	47.4	55.3	63.2
35″	17.3	26.0	34.6	43.3	51.8	60.6	69.2
40″	18.5	27.8	37.0	46.3	55.5	64.8	74.0
45″	19.7	29.6	39.4	49.3	59.1	69.0	78.8
50″	20.8	31.2	41.6	52.0	62.4	72.8	83.2
55″	21.8	32.7	43.6	54.5	65.4	76.3	87.2
60″	22.7	34.1	45.4	56.8	68.2	79.5	89.6
65″	23.6	35.4	47.2	59.0	71.0	82.6	94.4
70″	24.6	36.9	49.2	61.5	73.8	86.1	98.4
75″	25.1	37.7	51.0	62.8	75.4	87.9	100.2
80″	25.8	38.7	51.6	64.5	77.4	90.3	103.2
85″	26.1	39.2	52.2	65.3	78.4	91.4	104.4

No. 16 CONCEALED TYPE
For Walls permitting a 16 in. Recess

Overall Height	Length of Heater 12″	18″	24″	30″	36″	42″	48″
	Overall Length between End Trappings 18″	24″	30″	36″	42″	48″	54″
20″	24.0	36.0	48.0	60.0	72.0	84.0	96.0
25″	28.4	42.6	56.8	71.0	83.0	99.4	113.6
30″	31.6	47.4	63.2	79.0	94.8	110.6	126.4
35″	34.6	52.0	69.2	86.6	103.6	121.2	138.4
40″	37.0	55.6	74.0	92.6	111.0	129.6	148.0
45″	39.4	59.2	78.8	98.6	118.2	138.0	157.6
50″	41.6	63.4	83.2	104.0	124.8	145.6	166.4
55″	43.6	65.4	87.2	109.0	130.8	152.6	174.4
60″	45.4	68.2	90.8	113.6	136.4	159.0	179.2
65″	47.2	70.8	94.4	118.0	142.0	165.2	188.8
70″	85.2	73.8	98.4	123.0	147.6	172.2	196.8
75″	50.2	75.4	102.0	125.6	150.8	175.8	200.4
80″	51.6	77.4	103.2	129.0	154.8	180.6	206.4
85″	52.2	78.4	104.4	130.6	156.8	182.8	208.8

Note.—Standard sizes shown in bold type; other heights as shown in tables can be furnished at a small additional cost.

STANDARD CABINET WITH No. 8 HEATER

Length of Heater	Overall Length of Cabinet	Capacities Heights of Cabinets 20″	26″	38″
12″	19″	12.0	14.7	18.3
18″	25″	18.0	22.0	27.5
24″	31″	24.0	29.4	36.6
30″	37″	30.0	36.8	45.7
36″	43″	36.0	44.0	55.0
42″	49″	42.0	51.4	64.1
48″	55″	48.0	58.8	73.2

Depth of Standard Cabinet is 9 inches for all sizes.

DOUBLE CAPACITY CABINET WITH No. 16 HEATER

Length of Heater	Overall Length of Cabinet	Capacities Heights of Cabinets 20″	26″	38″
12″	19″	24.0	27.0	34.0
18″	25″	36.0	40.0	51.0
24″	31″	48.0	55.0	68.0
30″	37″	60.0	67.0	85.0
36″	43″	72.0	82.0	103.0
42″	49″	84.0	95.0	119.0
48″	55″	96.0	109.0	137.0

Depth of Double Capacity Cabinet is 17 inches for all sizes.

Heaters are tapped at both ends. Supply and Return Tappings are also provided underneath heaters for use when recess space is restricted.

Hoffman Specialty Co., Inc.

Main Office and General Sales Department

Waterbury, Conn.

A NEW PRODUCT *of the* HOFFMAN SPECIALTY CO., INC.

An Entirely Different Method of Home Heating will be announced early in 1929

The new HOFFMAN SPECIALTY is distinguished for its ability to warm the lower part of a room first, and to keep more of its heat in the comfort zone of the room, from the floor to the breathing line, than it does in the upper, unoccupied part of the room near the ceiling. In doing this it partly offsets the law that warm air rises.

HOFFMAN Engineers started with the fact that electricity offers a one hundred percent efficient source of heat. But being heating engineers of long experience, they developed this device along different lines than electrical engineers have ever attempted. Their first step was to jacket the electric heating element, starting circulation and convection. Their second step was to speed up the process by means of a motor and air turbine. Their third step was to change the path of warm air from vertical to horizontal. The resulting recirculation of warm air near the floor is shown by the chart at the bottom of the next page.

When its development as a heating appliance was complete, a final step was to enclose the Heating Element in a small, good-looking useful table. It may be moved about easily within the room or from room to room and may be used as a table, even when in operation.

A thermostat supplied as optional equipment, provides automatic temperature control, sensitive to a three degree change, and may be set to maintain any temperature desired.

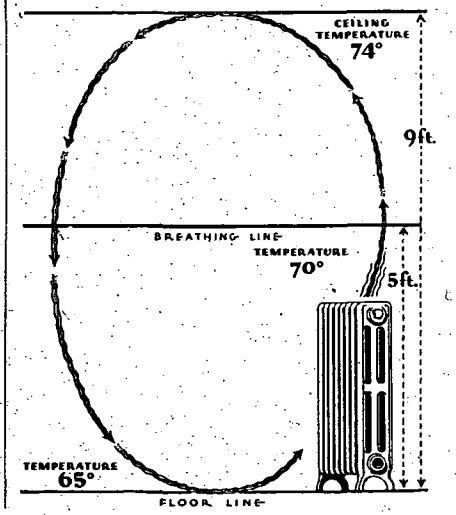
The operation of the turbine keeps the heating element at black heat rather than red hot. This makes the Heating Element perfectly safe and prevents it from burning out. If the turbine stops for any reason, the burning out of the heating element is prevented.

Warm air circulates through the Heating Element at the rate of 102 cu. ft. per minute without noticeable draft. The entire air content of the average room passes through it every 15 to 20 minutes. It has passed exhaustive laboratory tests and has been in service tests in approximately one hundred homes for over a year with entire satisfaction.

This new heating device will be made in various sizes from 1 to 4, KW capacity.

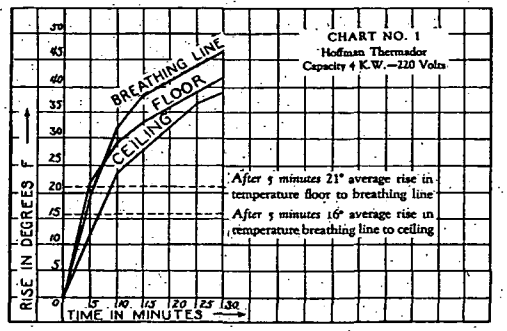
It can be used for complete home heating in mild climates or in localities with low electric rates and for auxiliary or occasional heating in colder climates.

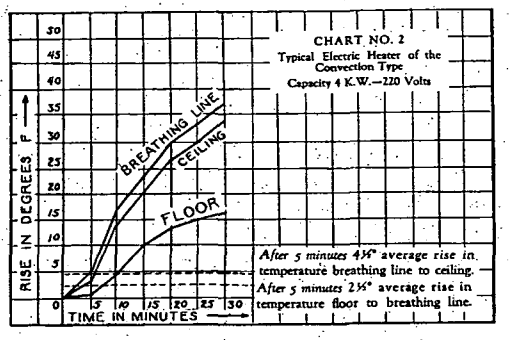
Complete catalog on request, upon publication. Address HOFFMAN SPECIALTY CO., INC., Waterbury, Conn.



Note the path of warm air circulating from a typical steam radiator installation. Note also the temperature readings at the floor, breathing line and ceiling. Compare these temperatures with those in the diagram on the opposite page.

These two charts, made from laboratory test data, compare the new HOFFMAN SPECIALTY with a typical electric heater of the convection type (which is comparable to a steam radiator). They show the relative speeds of heating, and the placement of heat within the room, by means of temperature readings taken every five minutes at the floor, breathing line and ceiling.





Charts showing efficiency of new HOFFMAN SPECIALTY speed of heating and placement of heat within the room compared with typical Electric Convection Heater.

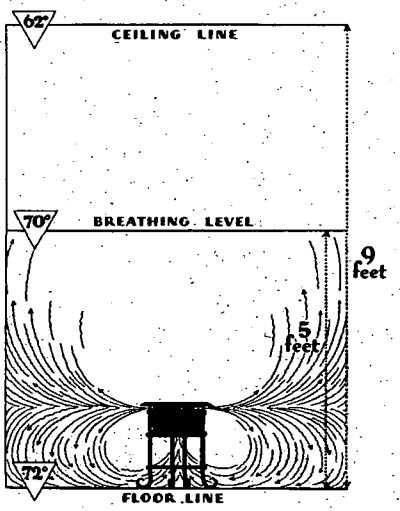


Chart Showing Warm Air Recirculation

When the Heating Unit is in operation, a horizontal strata of warm air is sprayed out on all sides from under the top. A small portion rises. But a continued drawing up of air from the floor level through the jacket of the Heating Unit, pulls most of the warm air down to the floor and recirculates it. Note the typical temperature readings at the floor, breathing line and ceiling.

The Trane Company

La Crosse, Wis.

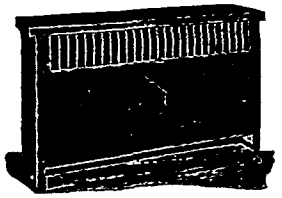
See Pumps, page 727; Unit Heaters, page 638
Heat Cabinets and Concealed Heaters, page 622, 623

BRANCHES IN ALL PRINCIPAL CITIES

TRANE HEAT CABINETS AND CONCEALED HEATERS

The Trane Company, pioneers in the field of convection heating, has designed three types of Heat Cabinets and Concealed Heaters to take the place of the conventional cast iron radiators on systems of every type. These three types—Heat Cabinets, Concealed Heaters, and Under-Window Concealed Heaters, make it possible to equip old as well as new buildings with this advanced equipment that has so many heating and fuel saving advantages.

HEAT CABINETS



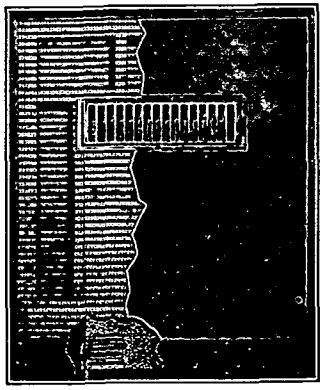
Trane Heat Cabinet

The Heat Cabinets are designed for installation in the room. A special cabinet of high grade furniture steel is placed over the heating unit and acts as a chimney to draw the air up over the unit and discharge it into the room parallel to the floor. These Cabinets are furnished with a special priming coat of paint that serves as a base for any special finish that may be required to blend with the interior decorations. Heat Cabinets are furnished in two styles—standard and double capacity. Positive heat control is obtained by use of an adjustable damper. Piping connections the same as on radiators—one inlet and one outlet.

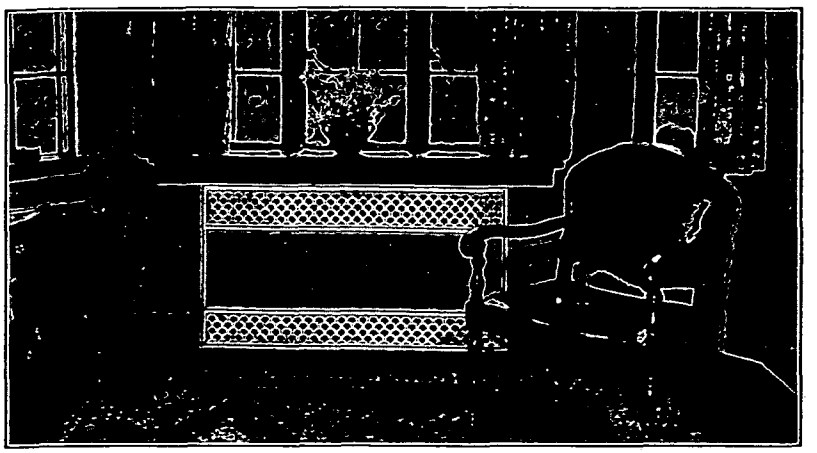
CONCEALED HEATERS

Trane Concealed Heaters are installed between the walls. All heating equipment is out of sight and out of the way leaving floor space free for furniture. A sheet metal stack is used to connect the copper heating unit and the outlet boot and grille. Capacities depend upon the length and width of heater and height of stack. Heaters furnished in 18, 24, 36 and 48 in. lengths and in 4, 6, 8 and 12 in. widths to fit in walls of standard construction. Heat control is obtained through use of shutter arrangement installed back of heat outlet grille. Heaters are installed back of the baseboard and are always accessible.

The Trane patented heating units used in connection with Heat Cabinets, Concealed Heaters, and Under-Window Concealed Heaters, are of copper construction. They are furnished in 4, 6, 8 and 12 in. widths.



Concealed Heater



Trane Under-Window Concealed Heater

TRANE UNDER-WINDOW CONCEALED HEATER

The Trane Under-Window Concealed Heater is a complete heating unit especially designed for installation in the walls under windows although it can be installed in other parts of the room with equal ease.

Complete, the unit consists of a metal wall box which fits between the studding and guides the heated air out into the room; a Trane patented copper heating unit; and a front metal panel which covers the front of the box and does away with the necessity of plastering in front of the unit.

Sizes.—The wall boxes are furnished in lengths of 18, 24, 30, 36, 42, 48, and 54 in., and in the same multiples of heights. They are available in widths to accommodate 4, 6, 8, and 12 in. heating units.

Construction.—The wall box and front panel are made of heavy gauge steel properly reinforced. The all copper heating unit is essentially the same in construction as the unit used in the Heat Cabinet and Standard Concealed Heater.

Heat Control.—Heat Control can be obtained in two ways—valve on the supply connection or by shutter control at heater outlet. Both methods give instantaneous response.

Installation.—The Under-Window Concealed Heater is meeting with great approval from architects, engineers, and heating contractors because of the simplicity of the installation. All that is necessary is to slip the wall box in the opening left by the carpenter, nail it to the studding, place the heater on the lugs, make piping connections and screw on the front metal panel.

Complete details on dimensions and capacities of Trane Heat Cabinets and Concealed Heaters will be sent on request

Skinner Bros. Mfg. Co., Inc.

Home Office 1490 S. Vandeventer Avenue, St. Louis, Mo.

Eastern Office 1013 Flatiron Bldg., New York, N. Y.

BALTIMORE	2 E. Lexington Street	DETROIT	2816 Eaton Tower Bldg.
BOSTON	921 Little Bldg.	KANSAS CITY	411 Mutual Bldg.
BUFFALO	1105 Walbridge Bldg.	PHILADELPHIA	1011 Pennsylvania Bldg.
CHICAGO	1701 Fisher Bldg.	PITTSBURGH	8 E. Lacock, N. S.
CINCINNATI	2160 Gilbert Avenue	SEATTLE	Railway Exchange Bldg.
CLEVELAND	603 Marshall Bldg.	SPOKANE	409 First Avenue
	WASHINGTON, D. C.		3500 14th Street, N. W.

Sales Offices in Principal Cities

Factories at ST. LOUIS, MO. and ELIZABETH, N. J.

Sole and exclusive manufacturers of Skinner Bros. (Baetz Patent) Air Heater, Skinner Bros. Direct Fired Heater, Skinner Bros. Lightweight Copper Heater, Skinner Bros. Revolving Siphon Ventilator, Skinner Bros. Slow Speed Low Power Dust Collecting System, Skinner Bros. Patent Fan Blast Dryer Outfit, and exhaust heads, blow piping, slow speed fans, buffing and emery wheel systems, machine guards.

SKINNER BROS. STEAM COIL HEATER

Recommended for heating, ventilating, air conditioning industrial buildings, regardless of size, whether of permanent or temporary construction, sawtooth or monitor, single or multistory. In paper and pulp mills, dyehouses, packing plants, laundries, dairies and buildings in which steam vapor, condensation and drippage are troublesome, Skinner Bros. Steam Coil Heaters are installed to eliminate these conditions. Installations in thousands of buildings throughout the country demonstrate their versatility and ability to heat buildings of any type of construction.



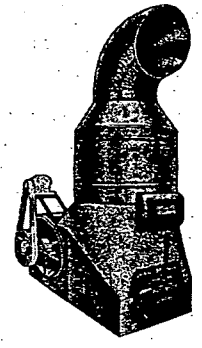
The New Skinner Bros. Two-Fan Four-Inlet Steam Coil Heater

Skinner Bros. Heaters are constructed in sizes and dimensions to fit all requirements demanded by various industries and different types of building construction.

Catalog will be furnished on request giving detailed capacities and dimensions.

Skinner Bros. Heaters may be operated with either live or exhaust steam, and high or low pressure may be used. The coils of every heater are tested with 150 lb. hydraulic pressure before leaving factory. The fan of the heater may be operated by electric motor, steam turbine, or gas engine.

SKINNER BROS. DIRECT FIRED HEATER



Skinner Bros. Direct Fired Heater is the outgrowth of a demand for equipment having the versatilities and efficiencies of the Unit Heater and not requiring a boiler. Buildings that are heated intermittently; buildings whose cost or use will justify only the least expensive heating apparatus; isolated buildings to which it is impractical to pipe steam for heating purposes, but which require warmth in winter; and buildings under construction in cold weather are found to be excellently suited to the Direct Fired Heater.

For fuel, coal, coke, wood, gas, or oil may be used.

Capacities 75,000 B.t.u. to 1,000,000 B.t.u.

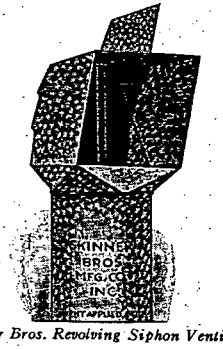
SKINNER BROS. REVOLVING SIPHON VENTILATORS

A roof ventilator designed to embrace the last word in efficiency and at the same time be so simple in construction that the possibilities of getting out of order are entirely eliminated. Skinner Bros. Revolving Siphon Ventilators, therefore, have shown themselves to require no attention whatsoever, once they are installed.

Operation: The slightest movement of air exerting pressure on the vane at the top moves the ventilator head to a position in which the open face is at right angle with the direction of the wind. In this position the air passes through the immovable shutter or louvres putting into operation the siphon principle which causes the foul air or fumes in the room below to be siphoned up the stack and out through the face of the ventilator.

Rain falling directly downward runs off the top, and when the rain or snow is blown in a slanting direction the face of the ventilator is automatically turned from the windward. Ball bearings and a hardened steel pivot bearing minimize all possible friction. A counter-balanced damper in the stack closes the ventilator when desired. Stocked in galvanized iron in 26 standard sizes, and made of sheet copper on order.

The following table is based upon the capacities of Skinner Bros. Revolving Siphon Ventilators operating in the average wind velocity of the ten largest cities in the United States. The wind velocities used are those reported by the U. S. Weather Bureau. Therefore, these figures are accurate for normal weather conditions in various parts of the country.



Skinner Bros. Revolving Siphon Ventilator

Size	Gauge	Cu. Ft. per Hr.
10	24	29,040
12	24	41,400
14	24	56,460
16	22	73,920
18	22	93,240
20	22	115,200
22	22	139,380
24	22	165,840
26	20	194,400
28	20	225,720
30	20	259,200
32	20	294,840
34	20	332,880
36	20	373,200
38	20	415,800
40	20	460,800
42	18	507,960
44	18	557,520
46	18	609,360
48	18	660,000
50	18	720,000
52	18	778,800
54	18	839,760
56	16	903,000
58	16	968,760
60	16	1,036,800

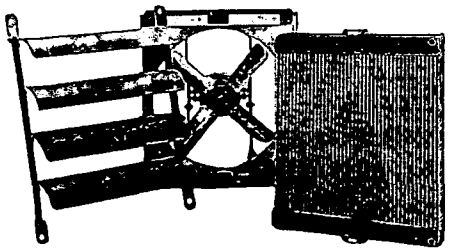
McQUAY RADIATOR CORPORATION

General Sales Office:

Pure Oil Bldg. **Chicago, Ill.**

NEW YORK: 2148 Graybar Building BOSTON: 164 Federal Street

Cabinet Radiators — Concealed Radiators — Unit Heaters



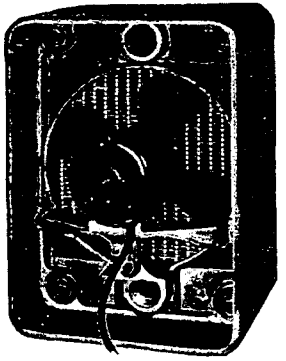
McQUAY *Unit* HEATER

The patented "Lock Seam" tubing —a distinctive McQuay development—overcomes the structural weaknesses of the ordinary type of condensers. No chance for seam separations or blow-outs.

The tubes are of heavy brass, tinned both inside and out, resisting rust and corrosion. The header plates are of heavy gauge copper. The tanks are cast in special bronze alloy.

The motor rests in a saddle, supported by two steel arms. Between the supporting steel band which surrounds the motor, and the motor itself is a quarter-inch band of cork which absorbs all vibration eliminating rattle and noise.

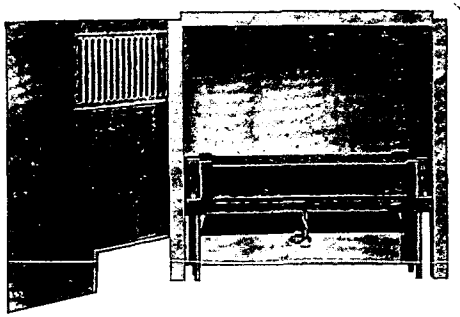
Every part is easily accessible—the entire heater is the simplest made, and factory tested under 100 lb. steam of 200 lb. hydrostatic pressure.



CAPACITY TABLE—Entering Air at 70 deg.

Model	Dimensions			Equiv. Sq. Ft. of Rad.	Tapped		Wght. Lb. Approx.
	Height In.	Width In.	Depth In.		Inlet In.	Outlet In.	
A660-S	26	22	15⅜	650	2	2	145
A550-S	26	22	15⅜	500	2	2	145
B330-S	18	15	12¾	300	1½	1½	82
B220-S	18	15	12¾	200	1½	1½	82
C150-S	13¾	10½	12½	137	1¼	1¼	52
C100-S	13¾	10½	12½	97	1¼	1¼	52
D80-S	13	7	8⅛	54	1	1	30

Write for Information on Larger Sizes



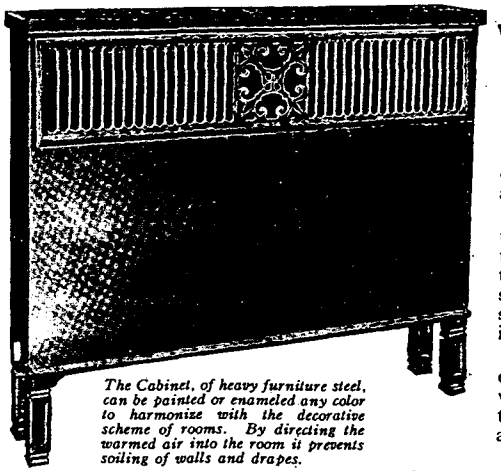
McQUAY *Concealed* RADIATOR

UNDER WINDOW AND STANDARD CONCEALED TYPES

Interior view of under window type (with front panel opened) showing heating unit. The front of the radiator closes flush with the wall—only an inconspicuous grille and an opening for admitting cold air are visible. The back of the steel cabinet is curved directing the flow of air into the room.

Nothing to get out of order—light in weight, compact and easily installed.

The heating unit of copper and brass provides an exceptionally effective combination of heating efficiency.



The Cabinet, of heavy furniture steel, can be painted or enameled any color to harmonize with the decorative scheme of rooms. By directing the warmed air into the room it prevents soiling of walls and drapes.

McQUAY *Cabinet* RADIATOR

Not just a radiator cover but a complete radiator enclosed in an attractive steel cabinet.

Cold air, from the floor, enters the cabinet at the bottom, passes through the heating unit and is then impelled into the room with sufficient initial velocity to insure positive circulation, resulting in far quicker heating.

A water chamber, inside the cabinet, provides the heated air with the moisture it must have to insure healthful and comfortable heat.

Series 500-S—5 in. in depth

Cabinet Lengths: 15, 17½, 20, 22½, 25, 27½, 30, 32½, 35, 37½, 40, 42½, 45, 47½, 50 in.

In any of the following heights: 20, 23, 26, 32, 38 in.

Equivalent to 9½ to 52½ sq. ft. of cast iron radiation.

Series 900-S—9 in. in depth

Cabinet Lengths: 15, 17½, 20, 22½, 25, 27½, 30, 32½, 35, 37½, 40, 42½, 45, 47½, 50, 52½, 55, 57½, 60, 62½ in.

In any of the following heights: 20, 23, 26, 32, 38 in.

Equivalent to 17 to 99 sq. ft. of cast iron radiation.

Series 700-S—7 in. in depth

Cabinet Lengths: 15, 17½, 20, 22½, 25, 27½, 30, 32½, 35, 37½, 40, 42½, 45, 47½, 50, 52½, 55, 57½, 60 in.

In any of the following heights: 20, 23, 26, 32, 38 in.

Equivalent to 16½ to 85 sq. ft. of cast iron radiation.

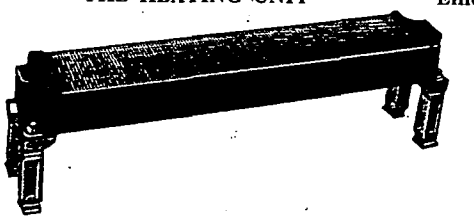
Series 1100-S—11 in. in depth

Cabinet Lengths: 15, 17½, 20, 22½, 25, 27½, 30, 32½, 35, 37½, 40, 42½, 45, 47½, 50, 52½, 55, 57½, 60, 62½ in.

In any of the following heights: 20, 23, 26, 32, 38 in.

Equivalent to 18 to 122 sq. ft. of cast iron radiation.

THE HEATING UNIT



A distinctive McQuay development consists of a series of flat, horizontal tubes, securely held in place by copper fins and firmly nested in bronze headers.

The tubes are tinned inside—the entire unit being immune from rust and corrosion. It will not "clog."

Indestructible—The patented "Lock Seam" tubing eliminates any chance for seam separations or blow outs.

The entire radiator is practically indestructible.

Efficient—The McQuay idea of heat convection through horizontal tubes has been many times proved to be the most efficient known. This, plus the great advantage of positive circulation afforded by McQuay Radiators results in far more efficient heating.

Simple to Install—The shipping weight of McQuay Cabinet Radiators is approximately 1.6 lb. for each square foot of radiation—a decided advantage when compared with the weights of equivalent cast iron radiation.

No "on the job" assembling is needed. Pipe connections are made with the heating unit, and the cabinet is then placed on it.

Low in Cost—Ease of installation, considerably less weight, and easier handling, keep the cost of McQuay Cabinet Radiators low.

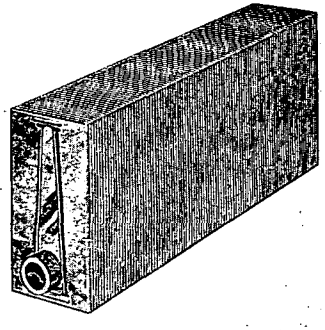
Actually—as proved in thousands of installations—the total cost installed is only slightly more than the cost of equivalent radiation of the old type.

The Herman Nelson Corporation

Moline, Illinois

Manufacturers of

Herman Nelson hiJet Unit Heaters; Herman Nelson Invisible Radiators; Univent Ventilation; Wedge Core Radiator Sections; Silentvent Exhausters



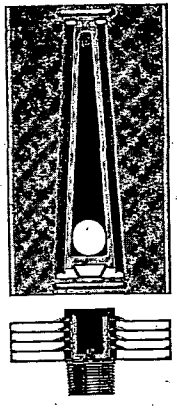
The Wedge Core RADIATOR INDESTRUCTIBLE TRADE MARK

The Herman Nelson Wedge Core Radiator has proven its worth as a practical means for air warming, air cooling, air condensing, air drying, etc., as demonstrated by the many installations in these various applications.

The radiator consists of a steamway or core upon which smooth, flat surface plates are firmly wedged in parallel, causing a tight metal to metal contact. As the core or steamway is cast of a special homogeneous metal in one piece, the liability of leakage is eliminated. It is leak-proof and rust-proof, and has no joints of any kind. It provides a construction that will withstand expansion and water hammer strains without injury.

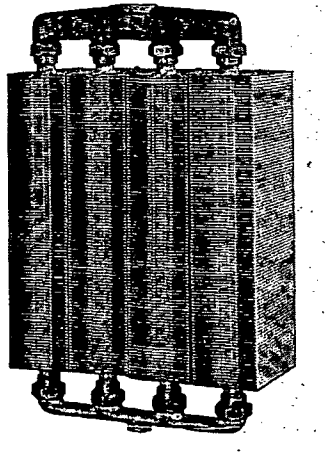
The core extends the entire length of the radiator and is tapered in cross section having an average thickness 1 in. and a 4½ per cent taper. The core is 6⅝ in. wide and the walls which are ⅛ in. thick are provided with stays through the middle on 4 in. centers.

The radiators are regularly tested to a hydrostatic pressure of 250 lb. and sections are selected at random from stock for a test of 500 lb. hydrostatic pressure. Operating pressures are guaranteed up to 150 lb.



DIMENSIONS

Herman Nelson Wedge Core Radiator Sections can be assembled in combinations to meet almost any requirement and may be used either vertically or horizontally. They are made up in sections 10 in., 14 in., 20 in., 30 in., 40 in. and 50 in. in length with four different plate spacings and the stubs are threaded for 1 in. pipe connections.



Supply and return manifolds will be furnished by the manufacturers for assemblies consisting of 2, 3, 4, 5 and 6 sections.

Where hot water or other liquids are circulated through the radiator, and the latter is used horizontally, it will be necessary to use vents which are located in the center of the section.

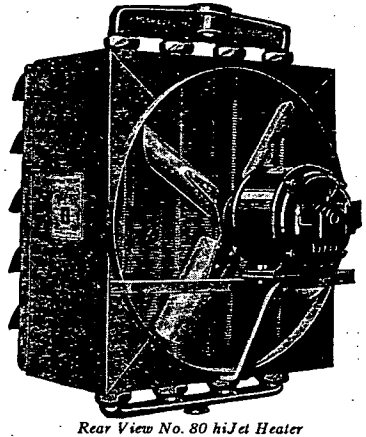
LIGHT WEIGHT AND PORTABLE

Due to the comparatively light weight of Herman Nelson Wedge Core Radiator Sections, they may be supported from the supply pipe headers—but where a large number of sections are so carried, adequate provision should be made for supporting the pipe lines. The weights vary somewhat, depending upon the spacing and size of the sections, but if an allowance of 31 lb. per square foot of face area in the block is allowed for each row, it will be sufficient to enable the proper determination of piping supports.

The Herman Nelson Corporation Engineering Department will appreciate an opportunity to cooperate on any problems involving this radiator.

HERMAN NELSON hiJet HEATER

This product is manufactured in three (3) sizes, referred to as Nos. 42, 80 and 180. The heating element in the hiJet Unit Heater is the Herman Nelson Wedge Core, leak-proof, jointless, indestructible radiator.



Rear View No. 80 hiJet Heater

Operating steam pressures up to 150 lb.

A long range projection of warm air to working level is provided.

The Her-Nel-Co motor furnished as standard equipment.

For description of the radiator see opposite page.

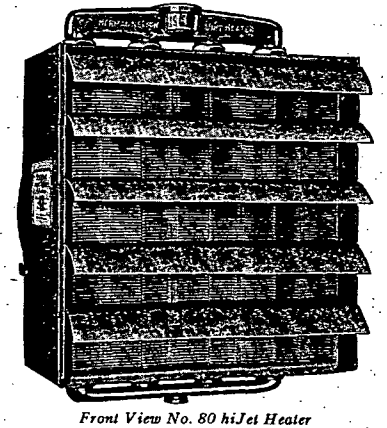
Light Weight Compactness Portability

Heaters Nos. 42 and 80 completely assembled, weigh approximately 92 and 170 lb. respectively. They are often hung on pipe lines thus reducing installation cost. The No. 180, largest of the line, weighs approximately 350 lb. and may be easily supported or moved.

Motors

Herman Nelson hiJet Unit Heaters are powered by Her-Nel-Co motors. Due to its lowered power cost, wider range of speeds and greater efficiency, the Her-Nel-Co motor is ideally fitted for hiJet Heater service.

Motors furnished regularly for two speed operation. Variable speed operation may be obtained through central control. These motors may be furnished for a standard voltage direct or alternating current, single phase or polyphase.



Front View No. 80 hiJet Heater

Fans

Fans for all three models are of the propeller type. They have been developed to provide highest efficiency, greatest air projection and the least noise, without sacrificing results.

The sheet aluminum blades are riveted onto a rigid steel spider, balanced after assembly and tested at full speed in the unit before shipping.

Capacities

The following schedule gives the capacities of the three models in equivalent direct radiation, entering air temperature 60 deg. with 2 lb. steam pressure.

	Model		
	42	80	180
Full Speed	260	485	1040
Slow Speed	185	348	750

For catalog and more detailed information address
THE HERMAN NELSON CORPORATION, Moline, Illinois.

John J. Nesbitt, Inc.

Executive Offices and Factory
State Road and Rhawn Street, **Holmesburg, Philadelphia**

Branch Office, 11 Park Place, NEW YORK

Sales and Service Through Offices of the American Blower Corp. In all the Principal Cities of the United States

PRODUCTS

1: *Universal Heating and Ventilating Unit for* SCHOOL ROOMS.

2: *Universal Unit Heaters for* LARGE ROOMS *like Banking Rooms, Show Rooms, Stores, Sales Rooms, Offices, Assemblies, Churches, etc.*

3: *Universal Concealed and Cabinet Heaters for* HOMES.

.1.

Universal Heating and Ventilating Unit for SCHOOL ROOMS

"Universal" has always been at the forefront in the use and development of the features that have made the Unit system universally accepted as ideal for schoolroom heating and ventilating. Among many other minor improvements, the Universal Unit introduced the light weight heater, the present-day form of unit with motor and fan assembly in base of cabinet, alternating current motors with rigid metal to metal mounting and the successful use of the blast system whereby direct radiation is eliminated from the class room.

"Universal" Multifin Copper Tube Radiator

Standard Universal Units are supplied with horizontal seamless copper tube radiators, the ends of the tubes of which are connected to cast iron headers by means of ground joints, thus being free of soldered, braised, welded or packed joints. Over these tubes are hydraulically pressed thin copper plates or fins, thus insuring real thermal contact between tubes and plates, making a highly efficient heating unit. Tested at 125 pound working pressure, and will stand freezing without breaking.

Motor

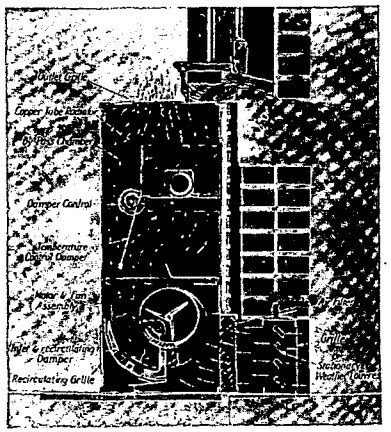
The motor of the "Universal" Unit is supplied for quiet operation on any character of current. The use of a motor generator set is no longer necessary with this system, but will be furnished upon request.

Three Point Lead Mounting

The Motor and Fan assembly of the Universal Unit is mounted in the cabinet on three steel ball points in contact with lead liners, making a very quiet operating unit, with no electrical noises. It has also made practical the use of alternating current motors with a permanent and rigid supporting device.

Fans

Universal fans are of the Sirocco type, aluminum, multiblade, low speed, double inlet, designed to operate at 800 r.p.m. plus or minus 5 per cent. No greater efficiency known. Volume regulators in discharge outlet permit precise control of air—another exclusive Universal feature. The by-pass chamber is parallel to heating



chamber and so located as to guide the column of cool air across the currents of warm air when mixing—thus creating an absolutely vertical discharge—and guide the cool air away from room occupants when completely by-passing. The large space between the fan and the radiator results in the uniform distribution and heating of entire air volume.

Thermostatic Control Optional

All Universal Units can be equipped with thermostatic and pneumatic attachments for pneumatic control of the inlet damper and thermostatic control of the by-pass damper. This equipment is optional.

Sizes and Capacities

Universal Unit Heating and Ventilating Cabinets for schools are obtainable in six sizes of cabinets, with six different air deliveries. Two different radiator sizes are available for each cabinet size. Thru the operation of the volume regulators, it is possible to obtain any delivery between the minimum of 450 c.f.m. and the maximum of 1500 c.f.m.

Refer to table of Capacities and Dimensions on pages 22 and 23 of the "Universal Heating & Ventilating Unit," publication No. 210—(A. I. A. File No. 30-d-11) for complete information. Send for this publication—as well as our Catalogue and Engineers Data Book.

.2.

Universal Unit Heaters for LARGE ROOMS

and beautiful interiors like Banking Rooms, Show Rooms, Stores, Offices, Assemblies, Churches, etc.

The Universal Unit Heater maintains a uniform temperature in the room—ceiling and floor alike—and it does this to the satisfaction of the heating engineer. It is also sufficiently attractive to meet the exacting requirements of the architect, and so quiet in operation as not to annoy those in the room.

Universal Unit Heaters are made on the same principles that have made the Universal Heating and Ventilating Unit for Schools so popular during the past 16 years. In them you will find the same high velocity vertical discharge, the same highly efficient Universal Multifin Copper Tube Radiator with its ground joint connections and its extra strength for more than working pressures and ability to stand up under freezing without breaking.

You will find the same low speed, long life, trouble free motor—either alternating or direct current—with the three point suspension of motor and fan on lead liners, making an assembly almost entirely free from operating noises.

You will find the same Sirocco type aluminum multiblade low speed double inlet fan. You will find the same volume regulators on the outlet of the fan housing so the air delivery of the Unit can be regulated to the requirements of the room.

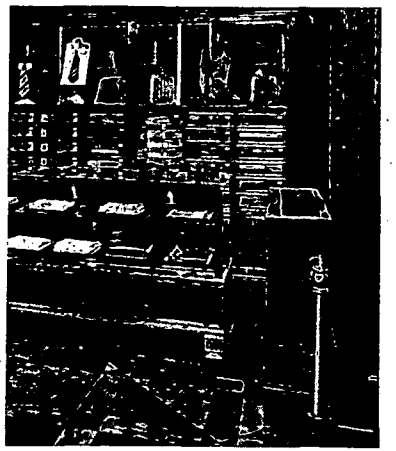
ADVANTAGES
of Universal Unit Heaters

Attractive in Appearance: Encased in a beautiful Cabinet of heavy high grade furniture stock steel.

Larger Heating Capacity in Smaller Space: Universal Unit Heaters with five times the heating capacity require but one-fifth the space taken up by direct radiators and can often be entirely concealed. This is especially important in centers of high rent where the best use must be made of all space.

Tremendous Saving in Fuel: High velocity heat diffusion from the vertical discharge results in uniform temperature over entire area, with only slight difference between floor and ceiling, effecting a tremendous saving in fuel by eliminating overheating of upper areas.

Quick Heating of Large Areas: Rapid circulation of air by low speed motor driven fans over a high efficiency copper tube radiator results in quick heating of



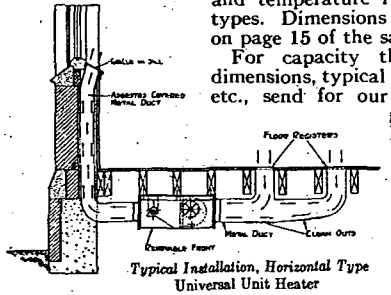
Typical installation in a Sales Room, where every inch of space is valuable, the Universal Unit *takes less space and is more efficient.*

large areas—a vital matter in the heating of churches and assembly rooms.

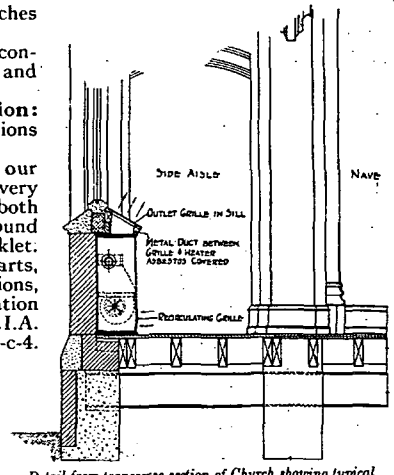
Temperature Control: Simple and effective control of room temperature by means of making and breaking electric contact in line to motor.

Less Expensive to Install than Direct Radiation: Piping system simplified and number of connections reduced, effecting a saving in labor and material.

Sizes of Heaters: The charts on page 14 of our Publication No. 209 give the heating capacity, air delivery and temperature rise for both types. Dimensions will be found on page 15 of the same booklet. For capacity these charts, dimensions, typical installations, etc., send for our Publication #209, A.I.A. File #30-c-4.



Typical Installation, Horizontal Type Universal Unit Heater



Detail from transverse section of Church showing typical Universal Unit *Installation.*

.3.

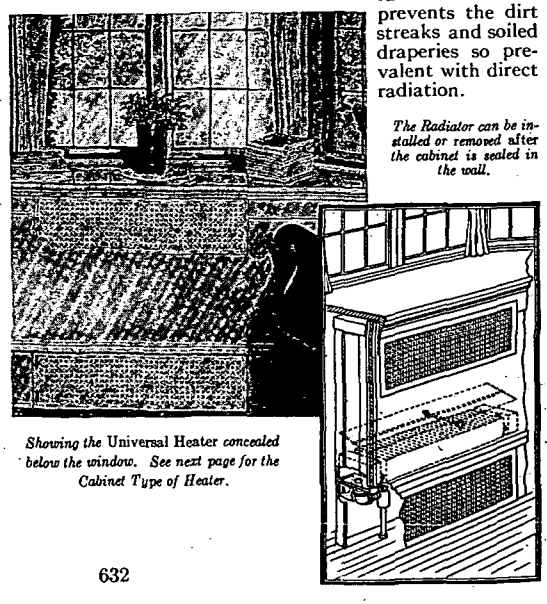
Universal Concealed and Cabinet Heaters FOR HOMES

With the Universal cabinet heater, the temperature of the floor is practically the same as at the ceiling—an impossibility with cast iron radiation. With cast iron radiators, temperatures are always considerably higher at the ceiling than the floor. Floor temperatures are seldom satisfactory, as the proper temperature is usually maintained for body comfort at about the height of a chair, leaving the floor chilly, uncomfortable and often a frequent cause of colds and sickness. The Universal Cabinet Heater corrects this condition.

Cleanest Form of Heating for Homes: The Universal cabinet heater discharges the heat outward and into the room, instead of against walls and ceilings, as with direct radiation. This prevents the dirt streaks and soiled draperies so prevalent with direct radiation.

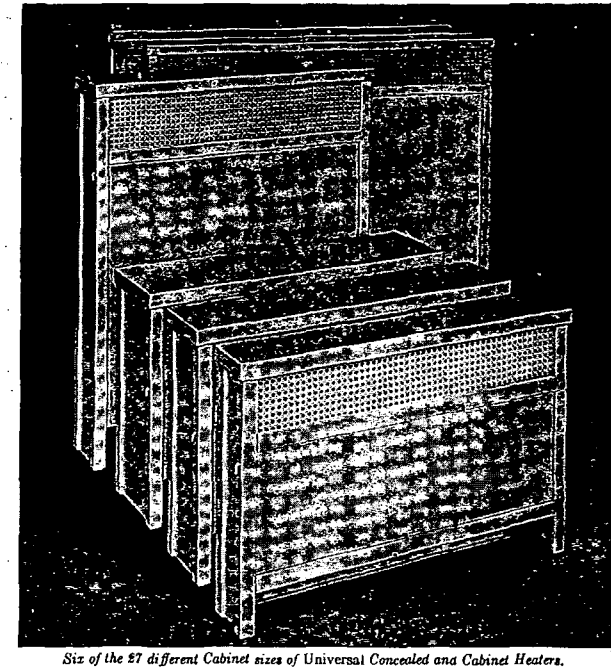
Cabinet Heater Dimensions and Capacities

W 4½ in.			W 6½ in.		
Equivalent Cast Iron Direct Radiation Sq Ft.	H	L	Equivalent Cast Iron Direct Radiation Sq. Ft.	H	L
13	20″	29″	18	20″	29″
20	20″	45″	30	20″	45″
25	20″	55″	40	20″	55″
17	26″	29″	25	26″	29″
24	26″	45″	40	26″	45″
29	26″	55″	45	26″	55″
20	36″	29″	33	36″	29″
30	36″	45″	50	36″	45″
40	36″	55″	60	36″	55″
W 8½ in.			**W 9½ in.**		
20	20″	29″	25	20″	29″
35	20″	45″	40	20″	45″
45	20″	55″	50	20″	55″
27	26″	29″	34	26″	29″
48	26″	45″	54	26″	45″
60	26″	55″	67	26″	55″
37	36″	29″	41	36″	29″
58	36″	45″	65	36″	45″
70	36″	55″	80	36″	55″



Showing the Universal Heater *concealed below the window. See next page for the Cabinet Type of Heater.*

The Radiator can be installed or removed after the cabinet is sealed in the wall.



Six of the 27 different Cabinet sizes of Universal *Concealed and Cabinet Heaters.*

15 *Advantages of* Universal Cabinet and Concealed Heaters

1. A combination of beauty with utility.
2. Can be painted or decorated to harmonize with furnishings and color schemes.
3. Efficient in performance.
4. Economical in operation.
5. Diffuses heat thoroughly.
6. Creates uniform temperature—ceiling and floor alike.
7. Leaves no cold spots in room.
8. Control of temperature positive and immediate.
9. Cleanest known form of heating.
10. Outward discharge prevents discoloration of walls, ceilings and draperies.
11. Requires considerably less space than cast iron radiation.
12. Can be installed without a change in design of the old heating system.
13. The entire front of the cabinet heater can easily be removed by housewife or maid for cleaning.
14. May be entirely concealed in wall if desired.
15. When concealed in wall, *the radiator is accessible.*

CONCEALED HEATER—Dimensions and Capacities

Stack Height Floor to Bottom of Grille Inches	W 4½ in.						W 6½ in.					
	Equivalent Cast Iron Direct Radiation Sq. Ft.	"L" Length Overall	Equivalent Cast Iron Direct Radiation Sq. Ft.	"L" Length Overall	Equivalent Cast Iron Direct Radiation Sq. Ft.	"L" Length Overall	Equivalent Cast Iron Direct Radiation Sq. Ft.	"L" Length Overall	Equivalent Cast Iron Direct Radiation Sq. Ft.	"L" Length Overall	Equivalent Cast Iron Direct Radiation Sq. Ft.	"L" Length Overall
10	15	29	17	45	30	55	20	29	25	45	48	55
15	16	29	20	45	32	55	22	29	28	45	51	55
20	17½	29	23	45	35	55	25	29	32	45	54	55
25	19	29	26	45	37	55	29	29	36	45	57	55
30	20	29	28	45	40	55	32	29	40	45	60	55
35	22	29	30	45	43	55	36	29	43	45	63	55
40	23	29	33	45	45	55	38	29	47	45	66	55
45	25	29	36	45	48	55	41	29	51	45	69	55
50	26	29	39	45	50	55	43	29	54	45	72	55
55	28	29	42	45	53	55	46	29	57	45	75	55
60	29	29	45	45	55	55	48	29	60	45	78	55
65	31	29	48	45	58	55	51	29	63	45	81	55
70	33	29	50	45	60	55	53	29	65	45	84	55
75	34	29	52	45	63	55	57	29	68	45	87	55
80	36	29	55	45	65	55	59	29	71	45	90	55
85	37	29	58	45	68	55	62	29	74	45	93	55

C=½ of W: example W4½ C=2¼ in. O=Stack Height floor to bottom of grille as given below plus 7 in.

Peerless Unit Ventilation Company, Inc.

Heating and Ventilating Systems -:- Industrial Heating Units

718-34 Crescent Avenue, **Bridgeport, Conn.**

Sales Offices

New York, N.Y., 369 Lexington Avenue
Boston, Mass., 80 Boylston Street
Buffalo, N. Y., 135 University Avenue
Harrisburg, Pa., 3603 Sharon Street
Springfield, Mass., 19 Edward Street
Warren Point, Bergen County, N. J.
Scotia, N. Y., 25 Wallace Avenue
Baltimore, Md., 204 Water Street
Oklahoma City, Okla., Frank Loeffler Supply Co.
Omaha, Neb., 1820 St. Mary's Avenue
Allentown, Pa., 15 South Fifth Street
Cleveland, Ohio, 1836 Euclid Avenue
Chicago, Ill., 808 Monadnock Building
Detroit, Mich., 1214 Lafayette Building
Minneapolis, Minn., 603 Washington Avenue
Portland, Ore., 927 Board of Trade Building

Canada: Darling Brothers, Ltd., 77 York Street, Toronto, Ont.

Products

"PeerVent" and "Peerless" Heating and Ventilating Units, for Schools, Hospitals, Libraries, Churches, Dormitories, Club Rooms, Theaters, Banks, Offices, Auditoriums and other Buildings where many people congregate.

"Peerless" Industrial Heating Units (used in place of cast iron radiators), for Factories, Garages and other Industrial Buildings.



"PeerVent" and "Peerless" Heating-Ventilating Units

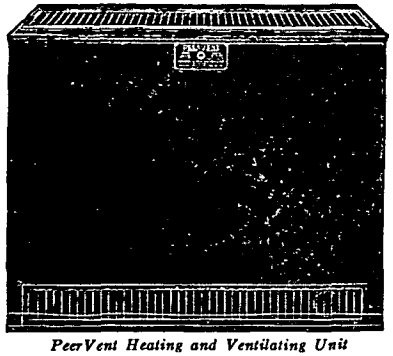
This Company makes two types of heating and ventilating units—"PeerVent" and "Peerless"—both intended for the same service but differing in design and construction. Only the PeerVent Unit is illustrated in these pages. Information about Peerless Units will be sent on request.

Features of the Improved "PeerVent" Unit

The PeerVent Unit of today has many important improvements, including the new PeerFin radiator. This radiator consists of two large copper alloy tubes, each surrounded by a series of closely spaced fins, also of copper alloy. The fins are embedded tightly into the tubes, so that under any conditions of expansion and contraction the fins and tubes are in perfect contact and there can be no loss of efficiency in the transfer of heat from tube to fin. The tubes are expanded into malleable iron headers, in the same manner that boiler tubes are expanded into the tube sheets, and the radiator assembly does not contain a single soldered, welded, brazed or gasketed joint. Test pressure, 150 lb.; operating pressure, 100 lb.

Another improvement in the new PeerVent Unit is the noiseless alternating current motor. This motor is of a design which has been developed after years of research and experimentation. It is mounted by means of a specially designed spring suspension, which precludes the possibility of noise caused by the transmission of phase vibrations. This motor is equipped with an auto-transformer, an integral part of the motor, for providing speed regulation within limits as close as obtainable with direct current motors. This feature saves power, as less current is consumed at low speeds.

The new PeerVent motor improvements are the final step in placing the unit system on a strictly unit basis. The motor-generator outfit is eliminated. The unit motors operate independently and there is no expense for current except for the unit or units that are actually in service. A single room can be ventilated without the operation of any apparatus other than the PeerVent Unit. There is also a considerable saving in the elimination of the first cost and operating cost of the motor-generator equipment.



PeerVent Heating and Ventilating Unit

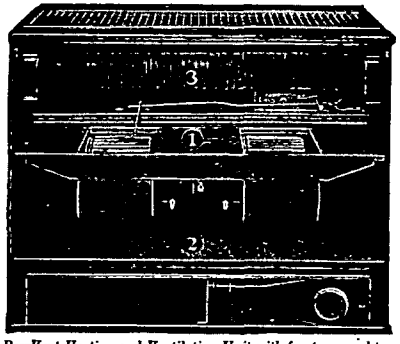
Other improvements in the new PeerVent Unit include a single-leaf damper which takes the place of the former interconnected fresh air and recirculation dampers, eliminating mechanical linkage. There are no mid-way positions of this damper: either the full volume of fresh air enters the unit or there is a complete recirculation of the air in the room. This damper, as well as the mixing damper, has been provided with improved bearings. The mixing damper can be equipped with any type of automatic temperature control.

New fan housings have been designed, providing larger discharge capacity at considerably lower tip speeds.

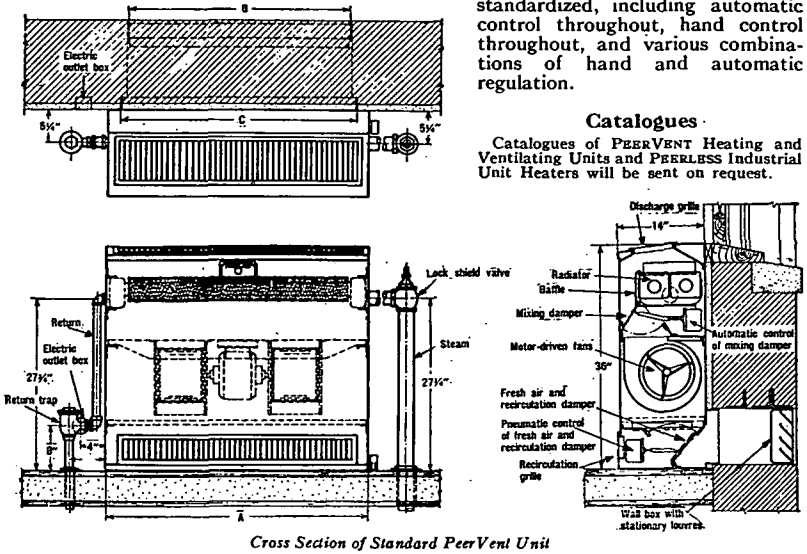
The mixing damper, radiator, motor and fan assembly, base assembly and air filter are all easily removable without the use of tools. The air filter, which is not included as part of the unit equipment, can be of any make preferred and can be installed after the unit has been erected, without any changes in the unit. The filter rests upon supports below the motor and fan assembly, sliding in and out of the unit like the drawer of a desk. With the filter in this position the air is cleaned before it reaches the fans, radiator, etc., and the dirt therefore does not reach these parts.

The new PeerVent Unit can be equipped with a positive-action PeerTherm Control, which automatically prevents the intake of cold air at any time when the room temperature falls below 65 deg. (or any other predetermined temperature within a range of 15 deg.)

Three types of PeerVent Units have now been standardized, and one or another of them will meet practically any architectural requirements, including installations in existing buildings. Six different types of control have also been standardized, including automatic control throughout, hand control throughout, and various combinations of hand and automatic regulation.



PeerVent Heating and Ventilating Unit with front removed to show interior parts. The fan housings (1) have been improved to provide greater discharge capacity at lower speeds. The air filter (2) is extra equipment, not included with the Unit, and can be of any make specified. The new PeerFin Radiator (3) is an important improvement. This view shows only one of the two rows of closely-spaced fins (see cross-section below).



Cross Section of Standard PeerVent Unit

Catalogues

Catalogues of PeerVent Heating and Ventilating Units and Peerless Industrial Unit Heaters will be sent on request.

Engineering Data—PEERVENT Heating and Ventilating Units

Unit No.	Maximum No. of Pupils	C.f.m. Delivered	Entering Air −10°					Entering Air 0°					Entering Air +10°				
			Final Discharge Temp.	Condensation, Lb. per Hour	B.t.u. Value (see note below) 1	2	3	Final Discharge Temp.	Condensation, Lb. per Hour	B.t.u. Value (see note below) 1	2	3	Final Discharge Temp.	Condensation, Lb. per Hour	B.t.u. Value (see note below) 1	2	3
36331	13	400	118.7	67.6	65500	15280 (61 Sq. Ft.)	25000	125	64.3	62400	14725 (58.9 Sq. Ft.)	27500	131.2	63.8	61700	14170 (56.6 Sq. Ft.)	32400
36332	16	500	113.7	81.2	78600		27700	120	77.3	74900		31200	126.2	73.5	71100		34400
36333	20	600	106.7	91.7	89000		28000	113	87.2	84500		32100	119.2	82.8	80100		37100
36334	23	700	100	101	97900		26700	106.3	96	92800		31700	112.5	89.7	87700		36300
36335	26	800	92.9	108	104600		23200	99.2	99	97800		27900	105.4	94.7	91700		33000
36336	30	900	80.7	108	104600		13100	87.1	99	97800		19200	93.3	94.7	91700		25700
36337	33	1000	72.1	108	104600		2800	78.4	99	97800		10400	84.6	94.7	91700		18300
36338	35	1050	.....	.....	.....		.....	72	99	97800		6100	78.2	94.7	91700		14600
36421	30	900	94.5	136.7	132600	19440 (77.75 Sq. Ft.)	41000	100.7	128.6	124500	18740 (74.96 Sq. Ft.)	45900	106.9	120.5	116600	18037 (72 Sq. Ft.)	50200
36422	33	1000	91	136.7	132600		30800	97.2	128.6	124500		37100	103.4	120.5	116600		43000
36423	35	1050	87.5	136.7	132600		25900	93.7	128.6	124500		32800	99	120.5	116600		39400
36424	36	1100	83.9	136.7	132600		20700	90.2	128.6	124500		28500	96.4	120.5	116600		35800
36425	38	1150	80.4	136.7	132600		15600	86.7	128.6	124500		24100	93.1	120.5	116600		32200
36426	40	1200	76.9	136.7	132600		10600	83.2	128.6	124500		19700	89.4	120.5	116600		28600
36427	41	1250	73.4	136.7	132600		5400	79.7	128.6	124500		15300	85.9	120.5	116600		25000
36428	43	1300	70	136.7	132600		.....	76.2	128.6	124500		10900	82.4	120.5	116600		21400
36429	45	1350	66.4	136.7	132600		.....	72.7	128.6	124500		6500	78.9	120.5	116600		17800
36511	40	1200	95.4	166.5	161000	23610 (94.4 Sq. Ft.)	38900	101.6	156	150900	22740 (90.9 Sq. Ft.)	46100	107.8	145.7	141000	21860 (87.5 Sq. Ft.)	52900
36512	43	1300	88.4	166.5	161000		28800	94.6	156	150900		37400	100.8	145.7	141000		45500
36513	45	1350	84.9	166.5	161000		23600	91.1	156	150900		33000	97.3	145.7	141000		41900
36514	46	1400	81.4	166.5	161000		18500	87.6	156	150900		28600	93.8	145.7	141000		38200
36515	48	1450	77.9	166.5	161000		13500	84.1	156	150900		24200	90.3	145.7	141000		34500
36516	50	1500	74.4	166.5	161000		8400	80.6	156	150900		19800	86.8	145.7	141000		30800
36517	51	1550	70.9	166.5	161000		3300	77.1	156	150900		15400	83.3	145.7	141000		27200
36518	53	1600	67.4	166.5	161000		.....	73.6	156	150900		11000	79.8	145.7	141000		23600
36519	57	1700	60.4	166.5	161000		.....	66.6	156	150900		.....	72.8	145.7	141000		16300

Note.—B.t.u. values are as follows:
1. With fans running.
2. With fans stopped.
3. B.t.u. available for heating purposes, over requirements for heating indicated c.f.m. to 70 deg.

Where values are not given, the discharge temperature is lower than we would recommend and we suggest the use of next larger size PeerVent.

Unit No.	Maximum Number of Pupils	Maximum Cu. Ft. per Minute	Dimensions Height.....36" Depth.....14" Length Overall Outside L	Fresh Air Intake 8½ x B B	Approximate Shipping Weight Lb.	Power Consumption in Watts	PIPING DATA Steam and Return—5⅛ in. from Back of Unit Height of Steam and Return Openings from Floor	Steam Size (see note) Gravity System	Steam Size (see note) Vacuum System	Return Size (see note) Gravity System	Return Size (see note) Vacuum System
36331	13	400				65		1½"	1¼"		
36332	60	500				75		1½"	1½"		
36333	20	600				85		1½"	1½"		
36334	23	700	33⅜"	27½"	300	100	27¾"	1½"	1½"	1"	¾"
36335	26	800				113		1½"	1½"		
36336	30	900				126		2"	1½"		
36337	33	1000				142		2"	1½"		
36338	35	1050				146		2"	1½"		
36421	30	900				115		2"	1¼"		
36422	33	1000				132		2"	1½"		
36423	35	1050				141		2"	1½"		
36424	36	1100				150		2"	1½"		
36425	38	1150	42⅜"	36½"	350	159	27¾"	2"	1½"	1"	¾"
36426	40	1200				168		2"	2"		
36427	41	1250				177		2"	2"		
36428	43	1300				186		2"	2"		
36429	45	1350				195		2"	2"		
36511	40	1200				162		2"	2"		
36512	43	1300				178		2"	2"		
36513	45	1350				186		2"	2"		
36514	46	1400				194		2"	2"		
36515	48	1450				200		2"	2"		
36516	50	1500	51⅜"	45½"	400	208	27¾"	2"	2"	1"	¾"
36517	51	1550				215		2"	2"		
36518	53	1600				222		2"	2"		
36519	57	1700				230		2"	2"		

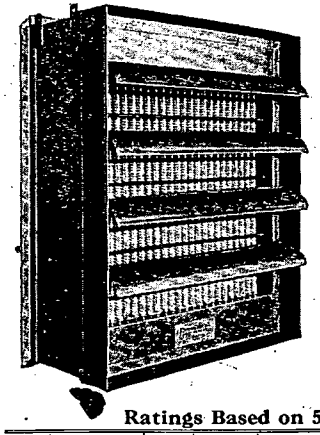
Note.—PeerFin Radiators are tapped 2 in. for both steam and return connections but can be reduced to sizes given in table. Eccentric reducers must be used. PeerFin Radiators can be connected with either right or left hand steam supply.

THERMIDAIRE

CORPORATION

2441-45 CHARLOTTE STREET

KANSAS CITY, MO.



Thermidaire Unit Heaters are **Quiet, Dependable** and **Efficient,** and when equipped with **Three Speed Motors** are **Unusually Quiet.**

Made in either **Floor or Ceiling Types** using **Propellor** or **Multi-Blade Fans,** and can be had in the capacities as listed. Dimensions for these types can be obtained from any agent or from the main office.

Recirculating Ducts, Direct Fired Units, and Ventilating Fans.

Table below applies to the type unit illustrated.

Ratings Based on 5 lbs. Steam Pressure at the Heater

Size	C.F.M.	H.P.	Rm. T	Disc. T	B.t.u.	E.D.R.	Height	Width	Depth	Supply	Return	Shipping Wt.
5	500 at 1140 r.p.m.	1/20	50 60 70	130 137 145	45,000 43,500 42,000	180 174 168	23⅛	15⅛	18	1¼	1	114
8	800 at 850 r.p.m.	1/12	50 60 70	135 141 145	76,800 72,000 67,200	304 288 269	26⅛	17⅞	18	2	1	137
10	1000 at 1140 r.p.m.	1/10	50 60 70	131 136 141	90,000 84,000 78,000	360 336 312						
15	1500 at 850 r.p.m.	1/8	50 60 70	135 140 145	143,600 134,800 125,900	575 540 504	30⅛	24⅛	18	2	1	176
20	2000 at 1140 r.p.m.	1/6	50 60 70	131 136 140	180,000 168,000 156,000	720 672 624						
25	2500 at 850 r.p.m.	1/8	50 60 70	131 136 140	225,000 210,000 195,000	900 840 780	33⅛	26⅝	18	2½	1¼	215
30	3000 at 1140 r.p.m.	1/3	50 60 70	125 130 136	252,000 224,000 216,000	1000 896 854						
40	4000 at 850 r.p.m.	1/4	50 60 70	131 136 141	360,000 336,000 312,000	1440 1344 1250	42⅜	34⅛	30½	2½	1¼	418
50	5000 at 850 r.p.m.	1/3	50 60 70	131 136 141	450,000 420,000 390,000	1800 1680 1560	47⅜	39⅛	32½	3	2	460
60	6000 at 690 r.p.m.	1/2	50 60 70	131 136 141	540,000 504,000 468,000	2160 2020 1870	51⅛	43¾	32½	3	2	500

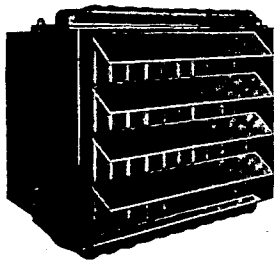
The Trane Company

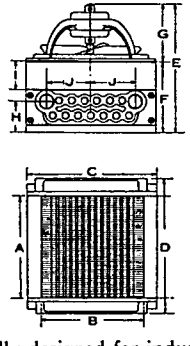
La Crosse, Wis.

See Pumps, page 727; Heat Cabinets and Concealed Heaters, pages 622, 623
Heating Specialties, pages 786, 787

BRANCHES IN ALL PRINCIPAL CITIES

UNIT HEATERS





UNIT HEATER DIMENSIONS

Heater No.	"A"	"B"	"C"	"D"	"E"	Pipe Tap.
12	12 1/16	12 1/16	15 1/4	16 1/16	15 1/4	1 1/4
18	18 1/16	18 1/16	22	22 7/16	16 3/4	1 1/2
24	24 1/16	24 1/16	29	28 7/16	22 1/2	2

Heater No.	"F"	"G"	"H"	"I"	"J"	Pipe Tap.
12	8 1/2	6 3/4	3 3/4	3 1/2	5 1/4	1 1/4
18	9	7 3/4	3 5/8	4	8 1/2	1 1/2
24	10	12 1/2	3 5/8	5	11 3/4	2

Trane Unit Heaters are especially designed for industrial installations but due to their quiet operation they can also be used in offices, assembling rooms, textile mills or wherever large open spaces are to be heated.

These units use an extended surface copper heating unit with the prime surface so arranged as to keep the entire secondary surface at an even, maximum temperature. Steam flows through vertical tubes which are rolled into cast iron headers. Fan of special Trane design 1, which delivers a large quantity of air at high velocity 1, is used. Motors of standard manufacture, enclosed type, are used on all heaters unless otherwise specified. Unit Heaters available for connection to outside duct work or recirculating boxes as well as for ceiling suspension.

CAPACITIES TRANE UNIT HEATERS—5 lbs. Steam Pressure

The following capacities are based on Direct Current or 60 Cycle motors. Capacities for 25 Cycle A. C. motors will be sent on request.

No. 12

Power Consumed	R.P.M.	Size Heater	C.F.M.	Inlet Air Temp.	Temp. Rise	Final Air Temp.	B.t.u. per Hour	Lbs. Cond. per Hour	Sq. Ft. Equiv. D.R.
75 watts	950	12" x 12"	625	50	71	121	47,500	49.5	198
75 watts	950	12" x 12"	625	60	67	127	44,800	47	187
75 watts	950	12" x 12"	625	70	63	133	42,100	44	176

No. 18

Power Consumed	R.P.M.	Size Heater	C.F.M.	Inlet Air Temp.	Temp. Rise	Final Air Temp.	B.t.u. per Hour	Lbs. Cond. per Hour	Sq. Ft. Equiv. D.R.
200 watts	1140	18" x 18"	1750	50	74	124	139,200	145	580
200 watts	1140	18" x 18"	1750	60	70	130	132,000	137	550
200 watts	1140	18" x 18"	1750	70	67	137	124,800	129	520

No. 24

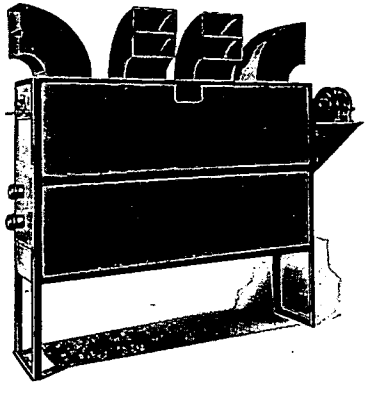
Power Consumed	R.P.M.	Size Heater	C.F.M.	Inlet Air Temp.	Temp. Rise	Final Air Temp.	B.t.u. per Hour	Lbs. Cond. per Hour	Sq. Ft. Equiv. D.R.
255 watts	1140	24" x 24"	2800	50	72	122	218,000	225	900
255 watts	1140	24" x 24"	2800	60	68	128	204,000	212	850
255 watts	1140	24" x 24"	2800	70	64	134	192,000	200	800

York Heating and Ventilating Corp.

York Bldg., 16th and Sansom Streets, **Philadelphia**

Branch Offices and Representatives in All Principal Cities

York Heat-Diffusing Units for Heating Factories, Shops, Garages, Etc.



Operating Economies:

1. High-velocity heat diffusion holds heat in the working zone until its principal energy has been utilized.
2. Reduces overheating of upper areas.
3. Heats large floor areas quickly.
4. A single Unit of correct capacity will heat uniformly a floor space up to 60 ft. by 200 ft. Comparatively few Units are required even for large plants.
5. The work of installation is reduced. Mains are shortened, and fewer branches and fittings are needed.
6. Fuel is saved through less overheating of upper areas; a shorter heating-up period; an easier control of room temperature.
7. Cost of complete installation will ordinarily range from 10 to 50 per cent below cost of direct radiation, pipe coils or central blower system.
8. York's large production makes possible a superior product at a relatively low price.

Heat-Diffusing Units, Housed Fan Type:

Five sizes and capacities are standard: Nos. 322, 333, 334, 344, 353. Sizes vary from 18 to 30 in. in width, 3½ ft. to 7 ft. in length. All units can be used on steam or hot water at pressures from 0 to 200 lbs. All are tested at 1000 lbs. hydrostatic pressure. Fresh air intakes and regulating dampers can be furnished at small extra charge.

NOTE.—These Units can be supplied for suspension where it is impossible to place them on the floor.

Kroy Unit Heaters, Disc Fan Type:

Five sizes are available for the few applications where this type Unit is suitable. Capacities range from 70,000 to 239,000 B.t.u. or the equivalent of 277 to 945 sq. ft. of Direct Radiation.

CAPACITIES

	Size Unit	R.p.m.	C.f.m. at Temp. in the Fans	H. P. Motor	Recirculating Air at 60°F. Entering Unit and Steam at 2 Lb. Gauge Pressure on the Heating Surface. (See footnote.) B.t.u. per Hour	Final Temp.	Lbs. Cond. per Hr.	Equiv. Direct Rad.	Air at 0°F. Entering Unit and Steam at 5 Lb. Gauge Pressure on the Heating Surface.* B.t.u. per Hour	Final Temp.	Lbs. Cond. per Hr.	No. of Air Outlets
YORK HEAT DIFFUSING UNIT	322	1750 1160	3,300 2,220	¾ ¼	208,000 148,000	124.4 128.7	217 154	867 616	297,000 211,700	92.0 98.1	310 221	2
	333	1750 1160	5,200 3,450	1½ ½	313,000 227,000	121.0 127.5	325 235	1300 945	447,000 325,000	87.0 96.5	465 338	3
	334	1750 1160	6,600 4,450	1½ ½	435,000 313,000	127.9 133.2	453 328	1812 1305	622,000 449,000	96.9 104.6	647 468	4
	344	1750 1160	8,400 5,600	2 ¾	550,000 400,000	127.0 134.0	570 415	2290 1665	785,000 571,000	96.5 105.7	816 595	4
	353	1160 870	13,000 9,820	3 1½	758,000 606,000	119.0 123.0	790 631	3160 2522	1,081,000 866,000	84.2 89.9	1128 903	3

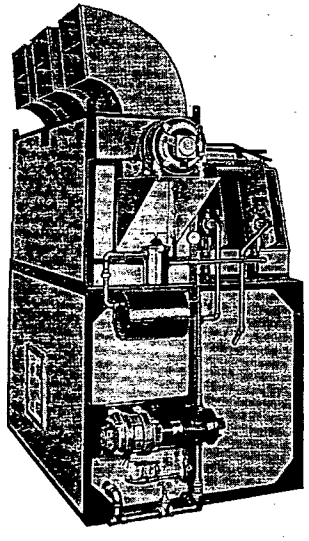
NOTE.—It is understood that the specified steam pressure is to be maintained on the heating surface. A suitable pipe line drop must be added in determining the pressure to be carried at the boiler. When air is to enter the unit at a temperature below freezing the steam pressure on the heating surface should be maintained at not less than 5 lb.

*See Chapter X of this issue of THE GUIDE for B.t.u. constants for other steam pressures and entering temperatures.

For 25-cycle speed and other ratings ask for complete Catalog.

York Air-Conditioning Units for Air Conditioning in Industrial Plants of All Kinds

YORK AIR-CONDITIONING UNIT



Unit System of Air Conditioning:

Complete air conditioning—heating and humidification in combination—in a compact, highly-developed unit.

The basis of operation is the York Heat-Diffusing Unit, amplified and developed to include the functions of scientific air conditioning.

Any floor or partitioned department may be controlled effectively as to atmospheric conditions, without reference to any other floor or department.

Operation:

The air passes through two spray chambers and a series of baffle plates. It is then heated and blown out horizontally at high velocity above the heads of the workers. This exclusive York feature makes possible an even distribution over a large area—and thereby reduces the number of units required.

Simple regulating controls, easily set, govern both temperature and humidity. An effectively conditioned atmosphere results.

Advantages:

Every Unit is mobile—can easily be shifted. The work of installation is simple. Complete flexibility of operation is possible.

Installation:

As these units are shipped completely assembled, the installation consists only in making connections to steam, water and electric lines, and providing an outside air connection.

Data Required:

Blue Prints and full information as to size and construction of building or department into which the Units are going; full information as to material to be conditioned and amount handled; available location for Units and location of steam, water and electric lines.

Air-Cooling Unit:

The York Air-Cooling Unit is a self contained completely assembled unit designed for use in cold storage rooms. Brine or ammonia is used as the cooling medium.

By automatic control any desired temperature, below normal, may be maintained.

York Super-Fin Extended Surface Copper Indirect Radiation for Central Blast Systems

YORK SUPER-FIN RADIATION

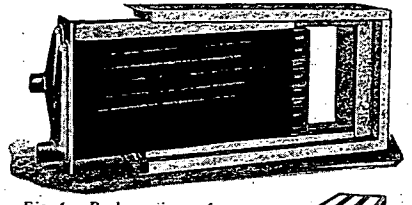


Fig. 1. By loosening a few bolts the end of the Super-Fin casing may be removed and the Super-Fin coil withdrawn. Note the supply and return are at the same end permitting end-to-end stacking as well as vertical.

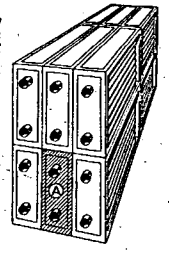


Fig. 2. When stacked if Unit A is to be cleaned only Unit A need be touched.

High or Low Pressure:

York Super-Fin is made in one type only, equally suitable for high or low pressure service. It is tested at 1000 pounds hydrostatic pressure and guaranteed for any working pressure up to 200 pounds.

Design:

A helical copper fin is actually imbedded in the heavy copper tube. The fin is perfectly smooth, without crimping. Tubes are of U-shape construction, fused to the headers. Supply and return are at the same end. Each Super-Fin unit is in a galvanized casing from which it may easily be withdrawn by loosening the bolts at one end.

Advantages:

(1) Three-side contact and bond between fin and tube. (2) *No joints to leak—every tube fused to header.* (3) High test pressure is assurance of durability under severe conditions including ordinary water hammer. (4) Supply and return at same end simplifies stacking. (Can be set end-to-end). (5) Removable from casing. Makes cleaning easy. (6) Smooth fin without crimping minimizes dirt collection and makes cleaning easier. (7) U-tube construction eliminates strains from expansion and contraction. (8) Drainage pitch in tubes permits casing to be level. (9) Cuts cost of installation by its easy handling and adaptability.

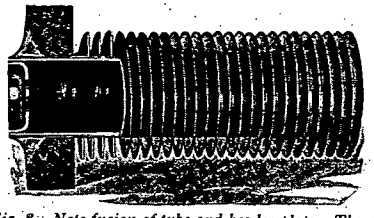


Fig. 3. Note fusion of tube and header plate. There are no joints to leak. Copper orifice ring gives equal steam distribution to all tubes. Fin imbedded in tubes gives 3-side contact.

Sizes:

The range of sizes enables Super-Fin to fit any condition. There are 1, 2, 3, or 4 nominal depths of pipe in one casing. Casings are 12 in. thick, several heights and lengths.

TABLE OF FACE AREAS IN SQ. FT.

Height of Section		Length of Casing			
Symbol	Dimension	32″	42″	62″	82″
A	17″	2.0	2.5	4.0	5.5
N	23″	3.0	4.0	6.5	9.0
U	29″	4.0	5.5	9.0	12.0
W	35″	5.0	7.0	11.0	15.0

NOTE.—In specifying Super-Fin sections add to the letter designation for size section the number of rows in depth desired—*i.e.*

N-1 means a section 23 in. high with 4 sq. ft. face area, one row deep.

Similarly, W-4 means a section 35 in. high with 15 sq. ft. face area, four rows in depth.

Complete rating catalog on request.

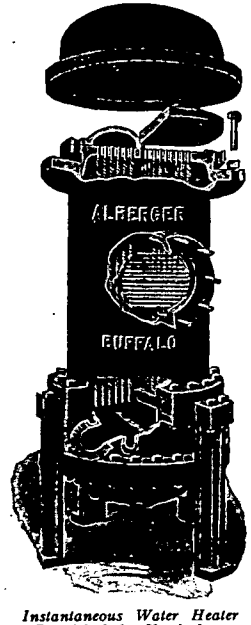
Alberger Heater Company

HOWARD IRON WORKS

218 Chicago St. :-: :-: :-: BUFFALO, N. Y.

REPRESENTATIVES IN PRINCIPAL CITIES

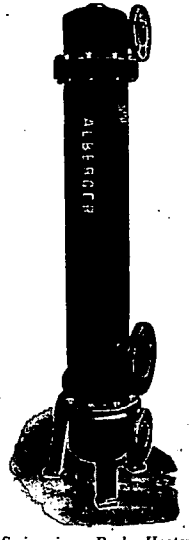
Heaters — Condensers — Coolers — Economizers — Expansion Joints



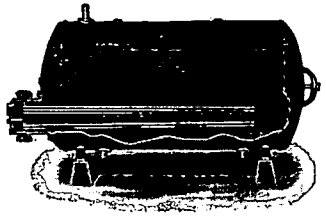
Instantaneous Water Heater Furnished in Vertical or Horizontal Type

Alberger-Buffalo Heaters are built in several types to meet a large range of standard and special water heating requirements. The standard instantaneous water tube type with floating heads is a highly efficient device embodying economy in space and maintenance cost. The storage water heater is used where the steam supply is intermittent or insufficient to take care of peak water demands. The swimming pool heater is especially designed for the purpose and is also extensively used with air washer equipment.

All of these heaters are built in either horizontal or vertical arrangement. **Alberger-Buffalo** equipment is widely used for many special requirements involving the heating or cooling of water and other liquids, and for the interchange of heat from one liquid to another.



Swimming Pool Heater. Single Pass Furnished in Vertical or Horizontal Type

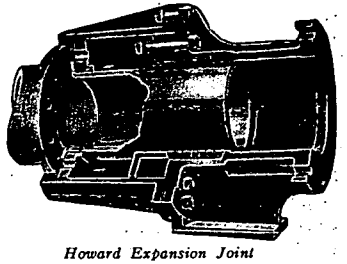


Storage Type Heater

ARCHITECTS ENGINEERS CONTRACTORS {**If you have not already done so, send immediately for a copy of the ALBERGER HEATER DATA BOOK which gives complete information regarding capacities and dimensions of our various types, as well as service and installation data. Also remember that our experience in designing and building special heaters and coolers is available to prospective clients.**

The Howard Guided Expansion Joint is a most satisfactory means for taking care of expansion in pipe lines because it is designed with only one object in view—100% service. The construction is mechanically correct—deep stuffing box—bronze sliding sleeve—totally enclosed construction to eliminate accumulation of dirt—exterior adjustment of packing gland—ready accessibility when packing is renewed. It is the most economical joint to use because it stays on the job and leaves a satisfied customer.

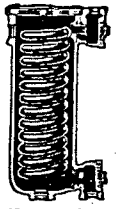
Send for—Bulletin XJ-3 for full details.



Howard Expansion Joint

Bell & Gossett Company

3000 Wallace Street **Chicago, Ill.**

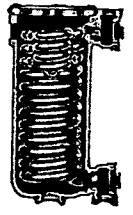


No. 30 and 45
30 and 45 Gallons
For small buildings and homes.

B. & G. Indirect Water Heaters are designed for use in smallest homes to the largest apartment buildings, country clubs, schools, etc.

In parts of the country where scale lime deposit and muddy water conditions prevail the *B. & G. removable coil feature allows for the taking out of the copper coil without disconnecting any pipes* (see cuts in folders).

Preheating fuel oil for larger installations (where industrial types of burners are used) is rapidly gaining favor. Special descriptive folder may be had on request showing exact size of heater to use on any specific job. Temperature degree rise 100° in three hours.

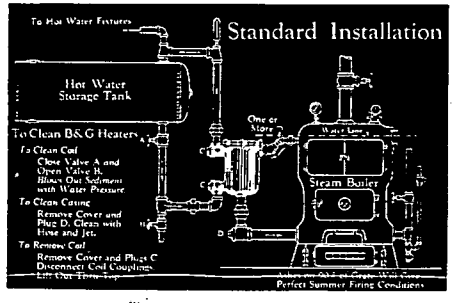


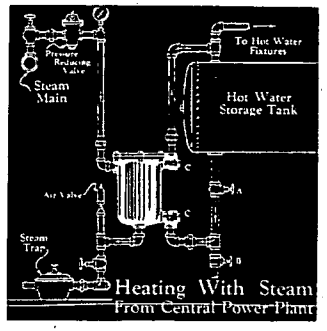
No. 160
160 Gallons
Double coil. A good size for apartments, garages and factory buildings.

BELL & GOSSETT COMPANY **WATER HEATERS**

Size and Type of Building — Residences and Apartments	Storage Tank Sizes to be Used up to 100 Apts.	Sizes of B. & G. Indirect Water Heaters. To use on Residences and Apartment Bldgs.	Size and Type of Building — Residences and Apartments	Storage Tank Sizes to be Used up to 100 Apts.	Sizes of B. & G. Indirect Water Heaters. To use on Residences and Apartment Bldgs.
Bungalows and Small Residences...	30 to 66 gal.	No. 30 No. 45 or No. 60	6 to 8 Apt. Bldgs...	315 to 365 gal.	No. 300 to No. 400
Medium Sizes to Larger Homes.....	66 to 150 "	No. 60 No. 90 or No. 120	8 to 12 " " ..	365 to 420 "	No. 400 to No. 600
Largest Homes, Three Baths and Up.....	150 to 295 "	No. 160 No. 200 or No. 300	12 to 18 " " .	420 to 575 "	No. 600 to No. 800
2 to 3 Apt. Bldgs....	120 to 180 "	No. 120 to No. 200	18 to 30 " " ..	575 to 865 "	No. 800 to Two No. 600
3 to 4 " " ...	150 to 220 "	No. 160 to No. 200	30 to 45 " " ..	865 to 1200 "	Two No. 600 to Two No. 800
4 to 6 " " ...	220 to 295 "	No. 200 to No. 300	45 to 60 " " ..	1200 to 1600 "	Two No. 800 to Three No. 800
			60 to 75 " " ..	1600 to 1800 "	Three No. 600 to Three No. 800
			75 to 99 " " ..	1800 to 2400 "	Three No. 800 and Up

Allow 25 to 50% Extra Heater Capacity to above Table if oil is used as Fuel. Tank sizes may remain same.





Davis Engineering Corp.

90 West Street, New York, N. Y.

Cable Address: "PARACOIL, NEW YORK" Factory: ELIZABETH, N.J.

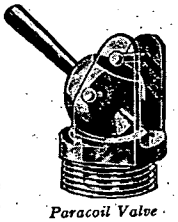
Manufacturers of Paracoil Steam Traps, Steam Specialties, Water Storage Heaters and other Heat Exchangers

Paracoil Products

STEAM TRAPS, FEED WATER HEATERS, FEED WATER FILTERS AND GREASE EXTRACTORS, STORAGE WATER HEATERS, OIL HEATERS, EVAPORATORS, EXHAUST GAS-STEAM GENERATORS, OIL COOLERS, DISTILLERS.

Paracoil Steam Trap

In this trap there is only one moving part, the solid recessed sphere which rotates over the valve seat. The trap is designed for all pressures, but 30 lb. steam pressure, 125 lb. and 200 lb., are carried in stock.



Paracoil Valve

The oscillating action of the valve makes possible a constant flow of condensate and the gouging action of the recessed ball keeps foreign matter from lodging between the valve and its seat. Capacities up to 75,000 lb. per hour.

The Paracoil Trap is guaranteed free from repairs for two years, providing installation and operating instructions are followed. Write for Catalogue A-12.



Paracoil Steam Trap

Paracoil Steam Trap

Trap In.	Capacity Sq. Ft. Radiation	Height In.	Length In.	Width In.	List Price	Wght Lb.
½	800	8½	8	8	$15.00	24
¾	1800	8⅜	10⅛	4⅞	20.00	28
¾ special	....	11½	11½	5½	25.00	36
1–1¼	4800	12¼	12	6⅛	35.00	50
1½–2	8000	16⅜	16	10¼	68.00	112
2½	12,000	18	19	11½	100.00	185
3	23,000	20	20¾	11½	125.00	212

Larger size traps on application.

Paracoil Storage Water Heater

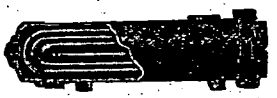
For heating and storing hot water for laundries, factories, hospitals, etc. The utilization of exhaust steam in this water heater effects a big fuel saving. Has steel plate shell for water and copper heating coils for steam. Pressures, 100 lb. standard and up. Sizes, 200 to 20,000 gallons per hour, heated to 180 deg. fahr. Fully described in Bulletin 74.



Paracoil Storage Water Heater

Paracoil Instantaneous Water Heater, U Tube Tank Heater, Preheater and Condensation Cooler

Connected below water level of boiler, heats water supply when fire is banked; unexcelled for indirect heating of private garages and conservatories.



Paracoil Instantaneous Water Heater

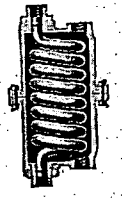
No.	Diameter In.	Length In.	Water Inlet and Outlet In.	Steam Inlet In.	Drain In.	Capacity Gal./Hr. 40–180° F. Steam Atmos.	W'ght Lb.
200	14½	34	2	2	1	200	250
300	14½	34	2	2	1	300	260
400	14½	47	2	3	1½	400	290
500	14½	47	2	3	1½	500	300
600	16½	50	3	4	1½	600	480
750	16½	50	3	4	1½	750	500
1000	16½	62	3	4	1½	1000	560
1250	16½	62	3	4	1½	1250	580
1500	19½	70	3	5	2	1500	962
1750	19½	75	3½	5	2	1750	1010
2000	19½	80	3½	6	2	2000	1083
2500	21½	81	3½	6	2	2500	1252
3000	21½	87	4	7	2½	3000	1301
4000	21½	99	4	8	2½	4000	1400
5000	21½	110	4	10	2½	5000	1481
7500	26	95	5	12	3	7500	1915
10000	26	108	5	14	3	10,000	2126
12500	26	120	5	14	3	12,500	2241

Nos. 200 to 1250 cast iron shell, and Nos. 1500 to 12,500 steel shell.

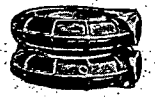
Paracoil U Tube Type Tank Heater

Size No.	Capacity, Gals. Below Water Level	Capacity, Gals. With Live Steam	Hot Water Radiation Sq. Ft.	Diam. In.	Length In.	W'ght Lb.
1	350	650	260	7½	27½	90
2	700	1300	520	11¾	40¾	220
3	1050	1900	780	14½	47	375
4	1350	2500	1000	16½	50	500

Larger sizes on application. Capacity rating, 100 deg. temperature rise in 3 hours (40 to 140 deg.). Capacity rating with live steam based on ½ lb. steam pressure.



Paracoil Indirect Resident Water Heater



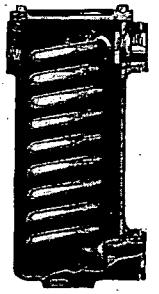
Paracoil Fire Pot Type Water Heater

Paracoil Indirect Resident Heaters, connected below water line of steam or vapor boilers. Paracoil Fire Pot type (for use in connection with Paracoil Indirect) for hot air furnaces or hot water boilers. Write for capacity and dimension data.

Excelso Products Corporation

65 Clyde Ave., BUFFALO, N. Y.

Excelso Indirect Water Heaters, Phaeton Heaters, Fire Pot Generators, Rotary Hack Saw Tools



Connect below water line of any Steam or Vapor Boiler, or use with live steam.

Boiling water in the shell heats water circulating through copper coil.

EXCELSO INDIRECT WATER HEATERS

Dimensions—Price List—Capacities

	Single Coil						Double Coil				Triple Coil	
Size	Jr.	11	12	13	14	15	25	26	27	28	35	36
Length In.	8½	10½	14	11½	15	19½	12½	15	19	23¼	21	25
Diameter In.	5	5	5	6½	6½	6½	9	9	9	9	13¾	13¾
Shell Open'gs. In.	1	1	1	1½	1½	1½	2	2	2	2	3	3
Coil Open'gs. In.	¾	¾	¾	1	1	1	1½	1½	1½	1½	2½	2½
Weight Crated Lbs.	11	13	16	29	37	42	65	73	88	106	185	210
List Price	$12.50	$30	$40	$50	$60	$70	$120	$150	$180	$210	$310	$400

Heating Water Below Water Line of Steam or Vapor Boilers

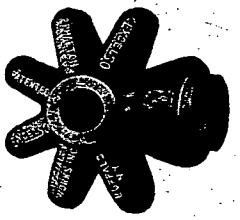
Size	Jr.	11	12	13	14	15	25	26	27	28	35	36
Tank Capacity	30	30	45	60	90	120	160	200	300	400	600	800

Temperature rise 100 deg. in 3 hours.

Heating Water With Live Steam

Size	Jr.	11	12	13	14	15	25	26	27	28	35	36
Tank Capacity	45	50	75	100	150	200	250	300	450	600	900	1200

Temperature rise 100 deg. in 3 hours at 5 lb. pressure.



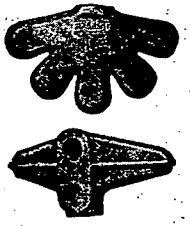


THE EXCELSO PHAETON HEATER

Dimensions—Price List—Capacities

Diameter In.	6	8	10	12	15	18
Height In.	3½	4½	5¼	6	7	8
Tappings In.	1	1	1½	2	2½	3
Center to Center of Outlets In.	2½	2½	3	3½	4½	5½
Capacity Gals.	30	45	80	100	150	250
Sq. Ft. Direct Water Radiation Ft.	40	75	100	150	250	400
Shipping Weight Lb.	6	11	18	30	60	85
List Price Iron	$7.50	$12.00	$20.00	$24.00	$50.00	$70.00
List Price Brass	$15.00	$28.00	$45.00	$54.00	$115.00	$160.00

The highly efficient firepot heater, suitable for hot water supply or auxiliary radiation, transfers 80 per cent of heat to water.



Excelso Firepot Generator

Generator fits any type of hot water boiler or hot air furnace. Made in both cast iron and brass.

Size No. 1, up to 40 gals. capacity.

Size No. 2, over 40 gals. capacity.

Excelso Rotary Hack Saw Tool



Boilers may be quickly and easily tapped by means of the Excelso Rotary Hack Saw Tool. Each tool cuts four sizes: 1 in., 1¼ in., 1½ in. and 2 in. Pipe Tap size.

Price $7.50 net, with eight blades; two of each size.

O. E. Frank Heater and Engineering Co., Inc.

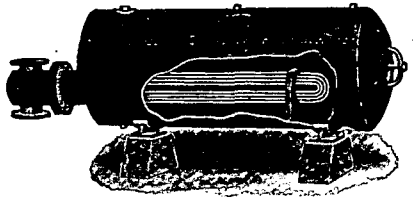
Offices in All Principal Cities

BUFFALO, N. Y.

O. E. F. Products.—U-Tube and Straight Tube Storage Heaters, U-Tube and Straight Tube Instantaneous Heaters, U-Tube and Straight Tube Feed-water Heaters, U-Tube and Straight Tube Swimming Pool Heaters, Bleeder Turbine Heaters, Domestic Service Heaters, Power Plant Heaters, Oil Coolers, Special Heat Exchange Equipment for Industrial Plants.

O. E. F. Storage Heaters are furnished in either the U-Tube or Straight Tube types to meet your requirements.

Tanks are made of high quality flange boiler steel. Tube Sheets of rolled steel, Castings of heavy gray iron, and Tubes of heavy gauge copper.



O. E. F. U-Tube Storage Heater

All Heaters, unless otherwise specified are constructed for a working pressure of 100 lb. Information for higher pressures furnished on request.

When it is necessary to use both high and low pressure steam, the steam chamber and tubes can be so arranged as to eliminate installation of a separate tube bundle.

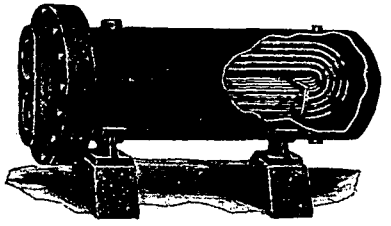
All tube bundles or heating elements are removable from the tank for ease in inspection, cleaning, or repairing.

O. E. F. Storage Heaters

For heating water from 50 to 180 deg. fahr. with steam at 212 deg. fahr.

Storage Capacity Gal.	141	370	940	1445	2956	2538	2961
Tank Size Inches	24 x 72	36 x 84	48 x 120	54 x 144	60 x 168	72 x 144	72 x 168
Gallons per Hour							
100	C-5	K-5	W-5	CX-5	MX-5	PX-5	RX-5
200	C-11	K-11	W-11	CX-11	MX-11	PX-11	RX-11
500	C-27	K-27	W-27	CX-27	MX-27	PX-27	RX-27
800	C-43	K-43	W-43	CX-43	MX-43	PX-43	RX-43
1000	.....	K-54	W-54	CX-54	MX-54	PX-54	RX-54
1500	.....	K-81	W-81	CX-81	MX-81	PX-81	RX-81
2000	.....	K-108	W-108	CX-108	MX-108	PX-108	RX-108
3000	.....	.....	W-162	CX-162	MX-162	PX-162	RX-162
5000	.....	.....	W-269	CX-269	MX-269	PX-269	RX-269

O. E. F. U-Tube Instantaneous Heaters and Economizers—An economical heater low in price but having high heating efficiency and made of best materials. Extensively used for heating



O. E. F. Instantaneous U-Tube Heater and Economizer

water instantaneously or for connection to storage tanks. Also for use as economizers in cooling condensate in steam systems or generators in hot water heating systems.

These heaters are adaptable for connecting below the water line of the boiler.

Capacities and General Dimensions O. E. F. U-Tube Instantaneous Heaters

Heating Water from 50–180 deg. fahr., with Steam at 212 deg. fahr.

Gallons per Hour	Size	Width In.	Length Ft.-In.	Steam In.	Water In.	Drain In.
100	U-6	11	4-9⅞	3	1½	1
500	U-15	13½	6-3¼	3	2	1½
800	U-24	13½	6-3¼	3	2½	1½
1000	U-30	16	6-3¼	3	2½	1½
1500	U-45	16	7-4¾	4	3	1½
2000	U-60	19	7-5¾	4	3	1½
3000	U-90	19	7-5¾	6	4	2
5000	U-150	22¼	7-7¾	8	4	3

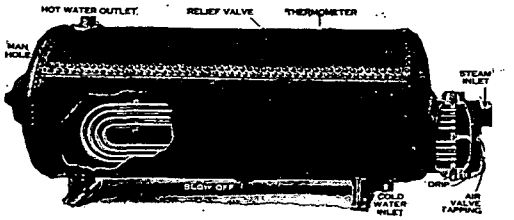
The Patterson-Kelley Co.

99 Park Avenue - New York City

Hot Water Heaters for all purposes. Pool Heaters and Converters. Preheaters, Heat Exchangers, Heaters for Chemicals, Gases, Oils. Coolers for Brine, Chemicals, Gases, Oil and Water.

The Patterson Combined Hot Water Service and Storage Heater, Type B, is for any service where requirements for hot water are not constant, or where a large volume must be stored for sudden heavy demands.

We guarantee to furnish heaters that will deliver the quantity of hot water called for. Without obligation our Engineering Department will be glad to give engineers the benefit of our 48 years' experience.



General Specifications

Constructed like a high grade boiler—of heavy steel plate. Steam inlet and outlet chamber is a heavy, grey iron casting. Tube head is a heavy, steel forging into which both ends of each tube are expanded. Tubes are of pure, cold drawn seamless copper and 'U' shaped to provide against contraction and expansion strains. Heater is for any service and in any required size per tables below. Write us for engineering advice.

STORAGE CAPACITIES

No.	Dimensions in Inches	Capacity in Gals.	Approx. Wt. in Lbs.	No.	Dimensions in Inches	Capacity in Gals.	Approx. Wt. in Lbs.
1 S	24 x 48	94	650	21 S	42 x 144	860	2450
2 S	24 x 60	118	750	22 S	42 x 168	1000	2800
3 S	24 x 72	141	850	23 S	42 x 192	1155	3100
4 S	24 x 84	164	950	24 S	48 x 96	750	2600
5 S	30 x 60	180	875	25 S	48 x 120	940	2925
6 S	30 x 72	215	1000	26 S	48 x 144	1125	3350
7 S	30 x 84	255	1150	27 S	48 x 168	1300	3840
8 S	30 x 96	285	1300	28 S	48 x 192	1500	4200
9 S	30 x 120	360	1500	29 S	54 x 120	1190	3500
10 S	36 x 72	310	1250	30 S	54 x 144	1425	3900
11 S	36 x 84	365	1400	31 S	54 x 168	1665	4300
12 S	36 x 96	415	1550	32 S	54 x 192	1900	4700
13 S	36 x 108	475	1700	33 S	60 x 120	1400	4300
14 S	36 x 120	500	1850	34 S	60 x 144	1700	4950
15 S	36 x 144	640	2100	35 S	60 x 168	2000	5600
16 S	42 x 72	430	1500	36 S	60 x 192	2240	6200
17 S	42 x 84	500	1650	37 S	72 x 174	3000	7000
18 S	42 x 96	575	1800	38 S	84 x 168	4000	8700
19 S	42 x 108	650	1950	39 S	96 x 168	5200	10000
20 S	42 x 120	720	2200	40 S	96 x 192	6000	11000

HEATING CAPACITIES—40° F. to 180° F.—Steam at Atmospheric Pressure

No.	Gallons per Hour	Approx. Wt. in Lbs.	No.	Gallons per Hour	Approx. Wt. in Lbs.
1 H	100	200	15 H	2000	700
2 H	150	215	16 H	2500	800
3 H	200	235	17 H	3000	900
4 H	250	255	18 H	3500	1050
5 H	300	285	19 H	4000	1200
6 H	400	315	20 H	4500	1350
7 H	500	350	21 H	5000	1500
8 H	600	370	22 H	6000	1750
9 H	700	400	23 H	7500	2000
10 H	800	425	24 H	10000	3200
11 H	1000	450	25 H	12500	3800
12 H	1250	500	26 H	15000	4500
13 H	1500	550	27 H	20000	5100
14 H	1750	600	28 H	25000	5800

NOTE.—To specify Type B. Heaters, combine the numbers of the required storage and heating capacities. For example, "One Patterson Type B. Heater with No. 22 S. and No. 17 H." has 1000 gallons storage with 3000 gallons hourly heating capacity.

The Whitlock Coil Pipe Company

Manufacturers and Engineers

HARTFORD, CONN.

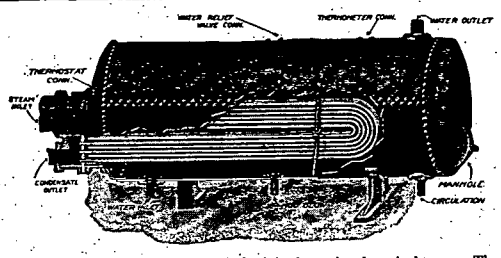
Baltimore, Md. Dallas, Tex.
Boston, Mass. Denver, Colo.
Buffalo, N. Y. Detroit, Mich.
Charlotte, N. C. Grand Rapids, Mich.
Chicago, Ill. Houston, Tex.
Cincinnati, O. Indianapolis, Ind.
Cleveland, O. Kansas City, Mo.

WHITLOCK SERVICE WATER HEATERS

Memphis, Tenn. San Antonio, Tex.
New Orleans, La. San Francisco, Calif.
New York, N. Y. Seattle, Wash.
Omaha, Neb. St. Louis, Mo.
Philadelphia, Pa. St. Paul, Minn.
Pittsburgh, Pa. Tacoma, Wash.
Portland, Ore. Troy, New York
Rochester, N. Y. Tulsa, Okla.

Darling Bros. Montreal, Manufacturers of Whitlock Heaters in Canada

See Telephone Directory for Local Address



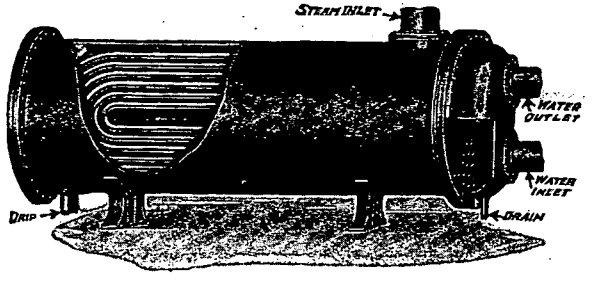
Whitlock type "K" storage heaters are manufactured in both horizontal and vertical types. The table shows sizes of the horizontal heaters only. We will gladly furnish dimensions of horizontal heaters and vertical heaters upon request. That this type of heater is of particularly sturdy construction is evidenced by the increasing number of prominent engineers and architects who are specifying their use in all types of buildings, including many of the largest and finest buildings constructed.

Whitlock Type K Storage Heaters, Horizontal

SHELLS — To be used with Type K Heating Section. Shell Prices include Cradle. Manhole 11"x15"							HEATING SECTIONS — Capacity based on Heating from 40° to 180° with Steam at 0 lbs. pressure. For other temperatures and Steam Pressures see Bulletin No. 27				
Number	Gallons One Filling	Diameter of Shell	Length of Shell	Thickness of Shell	Thickness of Head	Weight of Shell	Number	Gallons per Hour	Maximum Size Steam Pipe Inches	Smallest Shell into which Section will Fit Inches	Weight of Entire Heating Section Lbs.
1	65	18	60	1/4	3/8	400	H 0	100	2	18x 48	75
2	80	18	72	1/4	3/8	450	H 1	150	2	18x 60	80
3	118	24	60	1/4	3/8	600	H 2	200	2	18x 72	90
4	141	24	72	1/4	3/8	700	H 3	250	3 1/2	18x 48	175
5	164	24	84	1/4	3/8	800	H 4	300	3 1/2	18x 48	185
6	185	30	60	1/4	3/8	750	H 5	350	3 1/2	18x 60	190
7	220	30	72	1/4	3/8	850	H 6	400	3 1/2	18x 60	200
8	255	30	84	1/4	3/8	950	H 7	500	3 1/2	18x 72	210
9	290	30	96	1/4	3/8	1050	H 8	550	3 1/2	18x 72	215
10	365	36	84	5/16	1/2	1300	H 9	600	3 1/2	18x 84	220
11	420	36	96	5/16	1/2	1450	H10	700	5	24x 60	300
12	475	36	108	5/16	1/2	1600	H11	800	3 1/2	18x 96	260
13	525	36	120	5/16	1/2	1800	H12	900	3 1/2	18x108	270
14	575	42	96	5/16	1/2	1850	H13	1000	3 1/2	18x120	285
15	720	42	120	5/16	1/2	2150	H14	1250	5	24x 84	370
16	860	42	144	5/16	1/2	2500	H15	1500	5	24x108	425
17	1000	42	168	5/16	1/2	2900	H16	1750	5	24x120	450
18	950	48	120	3/8	1/2	2850	H17	2000	6	30x 96	570
19	1140	48	144	3/8	1/2	3250	H18	2400	6	30x120	620
20	1310	48	168	3/8	1/2	3700	H19	2800	6	30x132	670
21	1480	48	192	3/8	1/2	4100	H20	3200	8	36x 96	860
22	1190	54	120	3/8	1/2	3250	H21	3600	8	36x108	920
23	1430	54	144	3/8	1/2	3700	H22	4000	8	36x120	950
24	1670	54	168	3/8	1/2	4200	H23	4400	8	36x132	1020
25	1900	54	192	3/8	1/2	4700	H24	4800	10	36x 96	1200
26	1420	60	120	7/16	9/16	4300	H25	5400	10	36x108	1300
27	1710	60	144	7/16	9/16	4900	H26	6000	10	36x120	1380
28	2000	60	168	7/16	9/16	5600	H27	7000	12	42x 96	1950
29	2300	60	192	7/16	9/16	6200	H28	8000	12	42x 96	2000
30	2460	72	144	7/16	9/16	5700	H29	9000	12	42x108	2300
31	2880	72	168	7/16	9/16	6400	H30	10000	12	42x108	2460

DIRECTIONS FOR USE—Select the size storage you require and combine its designating number with the number which designates the desired hourly output. Assuming a required storage of 1000 gallons (No. 17 shell 42 x 168) and a required hourly output of 1750 gallons (No. H16 Heating unit) you would specify a Whitlock Type K, No. 17H16.

WHITLOCK TYPE R INSTANTANEOUS HEATERS



This type of heater is used extensively as an instantaneous heater in connection with a separate storage tank, as a swimming pool heater, as a hot water convertor for use with a heating system as well as for various special conditions.

Standard sizes of the 2 and 4 pass heaters are shown in the table. Dimensions on multi-pass heater will be furnished on request.

Standard Sizes, Capacities, Dimensions and Weights

Size No.	2 PASS, TEMP. RANGE 40° F. to 80° F.						4 PASS TEMP. RANGE 40° F. to 120° F.					
	Capacity Gallons per Hour	Over-all Length	Diameter of Shell	Size Water Connections	Size Steam Connections	Weight	Capacity Gallons per Hour	Over-all Length	Diameter of Shell	Size Water Connections	Size Steam Connections	Weight
0	150	11 3/8	7	3/4	1 1/4	80	80	11 3/8	7	3/4	1	80
1	350	14 5/8	7	1 1/4	1 1/2	90	150	16 5/8	7	3/4	1 1/4	100
2	650	19 5/8	7	1 1/2	1 1/2	110	300	21 5/8	7	1	2	115
3	1100	23 5/8	7	2	2	130	480	26 5/8	7	1	2	135
4	1600	29 5/8	7	2	2 1/2	145	650	31 5/8	7	1 1/4	2 1/2	150
5	1900	34 5/8	7	2	3	170	800	38 5/8	7	1 1/4	2 1/2	170
6	2550	24 3/4	9 1/2	2 1/2	3	240	960	24 3/4	9 1/2	1 1/2	3	220
7	3200	30 3/4	9 1/2	2 1/2	3 1/2	270	1350	30 3/4	9 1/2	2	3	270
8	3800	35 3/4	9 1/2	2 1/2	4	300	1600	35 3/4	9 1/2	2	3 1/2	300
9	5100	43 3/4	9 1/2	3	5	360	2100	43 3/4	9 1/2	2	4	350
10	6350	55 3/4	9 1/2	3	5	420	2600	55 3/4	9 1/2	2 1/2	5	420
11	7950	45	12	4	6	610	3300	52	12	2 1/2	5	620
12	9550	52	12	4	6	670	4000	61	12	3	6	700
13	12700	67	12	4	8	810	5300	79	12	3	6	860
14	15900	51 7/8	15	5	8	930	6600	55 7/8	15	3 1/2	8	940
15	19100	59 7/8	15	5	8	1040	8000	65 7/8	15	4	8	1070
16	25600	59	17	6	10	1320	10500	71	17	5	10	1390
17	31700	71	17	6	10	1510	13300	83	17	5	10	1580
18	38200	61 7/8	20	8	12	1940	16000	72 1/8	20	5	10	2020
18 1/2	44400	70 7/8	20	8	12	2100	18500	82 1/8	20	5	12	2230
19	50700	78 7/8	20	8	12	2300	21000	92 1/8	20	6	12	2430
19 1/2	57100	59 5/8	26	10	14	2870	24000	62 5/8	26	6	12	2800
20	63450	64 5/8	26	10	14	3020	26700	67 5/8	26	6	12	3000
21	79300	76 5/8	26	10	16	3500	33300	82 5/8	26	6	14	3480
22	95100	66	30	12	18	4250	40000	73	30	8	14	4015
23	126900	83	30	12	20	4780	53300	92	30	8	16	4600
24	158400	78	36	14	24	6550	66700	83	36	10	20	6100
25	191000	89	36	14	24	7060	80000	95	36	10	22	6900
	Sizes 0 to 10 inclusive, have 3/4" O. D. No. 18 B. W. G. Copper Tubes. Remainder have 1" O. D. No. 17 B. W. G. Copper Tubes.						Sizes 0 to 10 inclusive, have 3/4" O. D. No. 18 B. W. G. Copper Tubes. Remainder have 1" O. D. No. 17 B. W. G. Copper Tubes.					

Whitlock Heat Transfer Products include the following types of apparatus in addition to the Storage and Instantaneous Heaters shown above: Feed Water Heaters; Heat Exchangers; Fuel Oil Heaters; Superheaters; Condensers and Coolers for all kinds of liquids; Also pipe coils of any kind of pipe or tubing and Air and Ammonia Receivers.

Additional information and quotations covering any of this apparatus will be gladly furnished upon request.

Carrier-Lyle Corporation

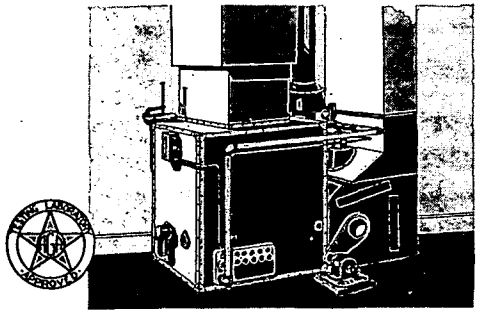
39 Cortlandt Street, New York, N. Y.

Affiliated with the Carrier Engineering Corporation

THE CARRIER WEATHERMAKER

A SCIENTIFIC AIR-CONDITIONING SYSTEM FOR HOMES

Compact new gas-burning unit for homes introduces a warm-air heating system that is clean; positive in circulation of air; healthful; and automatic in operation.



A complete heating and air-conditioning system for homes in winter. Approved by American Gas Association *Testing Laboratory. Made to take summer cooling unit, (now under development), without change in present system.*

The Carrier Weathermaker makes indoor weather to order.

1. It controls the moisture content of the air, maintaining a fixed, healthful relative humidity.
2. It warms the air, using manufactured or natural gas as fuel.
3. It filters the air, removing dust, dirt and bacteria.
4. It circulates the air by centrifugal blower, insuring positive, uniform distribution of heat.
5. It operates automatically.

In controlling warmth, humidity and air motion, the Carrier Weathermaker represents an original and constructive improvement in house-heating.

Development—The Carrier Weathermaker is an adaptation, for domestic use, of the well-known Carrier Systems now operating in nearly 3000 theatres, stores, factories and other large buildings.

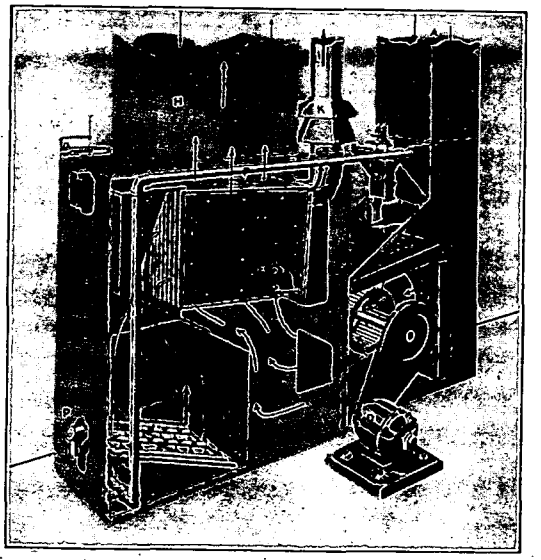
Operation—The simplicity of the Carrier Weathermaker is indicated by the diagram on opposite page. Air enters through return duct (A)—passes through filters (B) into blower (C) and is forced out under uniform pressure into heat-interchanger (E), where it is warmed. It rises to (F), where humidity is furnished by humidifier (G); then passes into mixing chamber (H) and is returned to rooms through warm-air ducts. Circulation is continuous and positive.

Combustion—The heat is supplied by gas burner (J). Combustion chamber and gas passages are entirely separate from the air passages.

The Carrier Weathermaker operates with an overall efficiency of 90 per cent.

Temperature Regulation—The thermostatic control mechanism (M) operates a throttling valve on the gas line. It regulates the gas supply to the demand for heat.

Protective Controls—A thermostatic pilot control (P) operates to close the main gas supply should pilot go out or gas-flow fail; a heat-limiting control (N) turns off the gas supply before overheating, through any cause, can occur.



Solid arrows show air travel. Outline arrows indicate combustion gases.

Filters—The air is cleaned by oil-coated, metallic-fiber filters.

Humidity Control—Moisture is added to the circulating air by the humidifier (G). Once adjusted to provide the desired relative humidity of the house atmosphere, the humidifier functions automatically.

Positive Circulation of Air—The blower provides forced circulation of air throughout the house. It is indirectly driven by a separately-mounted electric motor.

Non-corroding Construction—The combustion chamber and interchanger are made from a special nickel-chrome steel which is leak-proof and impervious to rust and acids.

Space Economy—The forced distribution of air permits the Carrier Weathermaker to be placed anywhere in the cellar, with resulting economy of space. It permits, also, the use of smaller ducts and long runs.

RATINGS, CAPACITIES, GAS CONSUMPTION, WEIGHTS

Weathermaker Number	Output B.t.u. per Hour	Fan Capacity Cubic Feet per Minute	Motor Horsepower	Gas Consumption Cubic Feet per Hour*	Approximate Shipping Weight Pounds
1	75,000	600	1/8	155	800
2	155,000	1200	1/6	318	1100
3	225,000	1800	1/4	455	1400

*Gas consumption figures based on manufactured gas of 550 B.t.u. and 3½ in. water gauge at pressure regulator. (*A. G. A.* Standard).

DIMENSIONS

Weathermaker Number	Overall Length	Overall Width	Height	Height Including Draft Diverter	Size of Return Air Opening	Size of Air Discharge Opening	Size of Gas Supply Line	Diameter of Flue Conn.
1	6'-3⅜"	3'-3½"	3'-11⅜"	4'-10"	12" x 14"	11" x 22"	1"	7"
2	6'-3⅜"	4'-2⅞"	3'-11⅜"	4'-10⅜"	12" x 25⅜"	22" x 22"	1¼"	8"
3	6'-3⅜"	5'-2¼"	3'-11⅜"	4'-11⅜"	12" x 36¾"	22" x 33"	1½"	9"

C. C. Shipp & Company

Indianapolis, Indiana, U. S. A.

AUTOMATIC

Trade Mark **D-I** Reg. U. S. Pat. Office

SANITARY

VENTILATING RADIATOR UNITS

for

SCHOOLS, HOSPITALS AND OTHER PUBLIC BUILDINGS

Three vital and important factors are assured by the use of the Automatic D-I Sanitary Ventilating Radiator Units

HEAT.....Distributed properly and automatically to every corner of the room.

MOISTURE.....In just the proper percentage assured automatically and without noise.

VENTILATION.....Controlled automatically by the temperature within the room, without draughts and without the use of mechanical appliances of any kind, or the services of an expert operating engineer.

Thus it will be seen that the D-I System is a natural, easy, simple, efficient and economical way of obtaining heat, ventilation and humidity for old and new buildings

---

See Pages 653, 654, 655, 656.

Copyright 1927, 1928, C. C. Shipp & Company

CAPACITIES OF D-I SANITARY VENTILATING RADIATOR UNITS

Series No.	Size of D-I Wall Box In.	Cu. Ft. Air per Minute	C. f.m. Air per Pupil	No. of Sections in Radiator	Sections of Radiator Covered
1	8 x 20	180	30	12	8
2	8 x 24	240	30	14	10
3	8 x 30	300	30	16	12
4	10½ x 20	270	30	14	10
5	10½ x 24	330	30	16	12
6	10½ x 30	420	30	18	14

(1) D-I Ventilating Wall Box with Storm Louvers, Insect Screen, Adjustable Extension Sleeve and Adjustable Controlling Fresh Air Damper with dust-proof and non-corroding hinges.

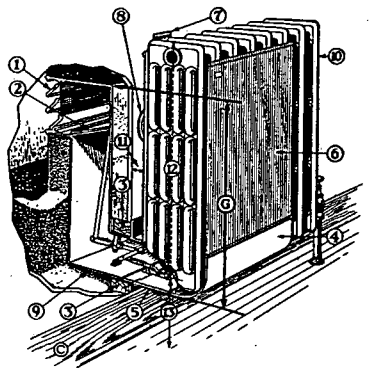
(2) D-I Adjustable Controlling Fresh Air Damper.

(3) 2 x 4-inch Wood Frame around ends, top and bottom of Sleeve, room side—Edge to set flush with finished plastering.

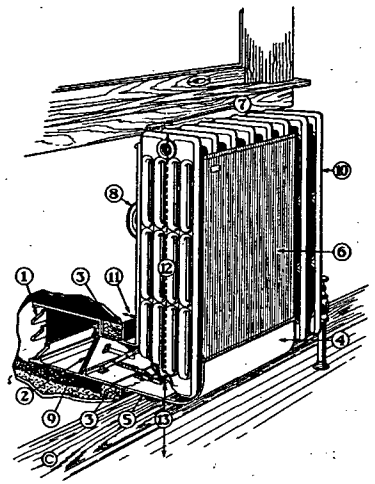
(4) D-I Sanitary Ventilating Box Base.

(5) Recirculating Air Damper and Clean-out Door.

(6) D-I Adjustable Air Diffusers with Removable Rolls.



Patented *Model B*



Patented *Model S*

(7) D-I Adjustable Fresh Air Damper Indicator.

(8) D-I Automatic Fresh Air Damper Control.

(9) Bottom of Wall Box Sleeve to set not less than 8 in. from finished floor.

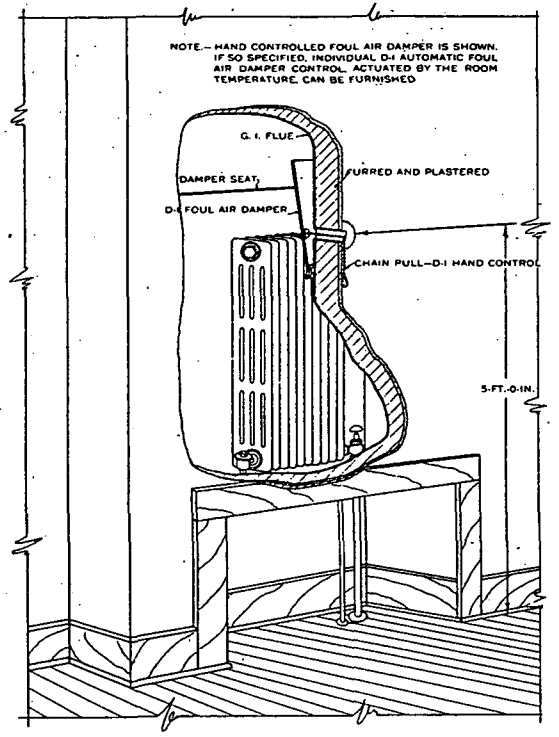
(10) 38-in. Five Tube Ventilating Legless Radiator—Bracketed from wall.

(11) Back of radiator to set 2¼ in. from finished wall.

(12) From center of lower tapping to extreme top of radiator—33½ in.

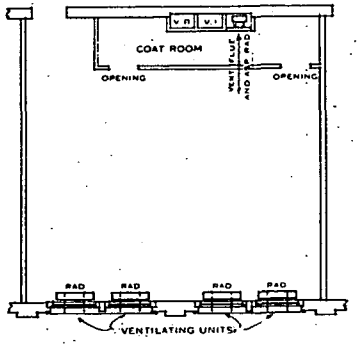
(13) From finished floor to center of lower radiator tapping—11⅛ in.

Copyright 1925, 1926, 1927, 1928, C. C. Shipp & Company



TYPICAL DETAIL VENT FLUE AND ASPIRATING RADIATOR

NOTE:—BOTTOM OF RADIATOR TO SET NOT LESS THAN 2-INCHES ABOVE TOP OF OPENING.



TYPICAL DETAIL OF CLASS ROOM

(IDEAL ARRANGEMENT AS DESIGNED BY JACOB H. HILKENE, SUPT. BUILDINGS AND GROUNDS, INDIANAPOLIS PUBLIC SCHOOLS, AND APPROVED BY THE BOARD OF EDUCATION.)

Methods of Calculation Applying to Gravity Ventilation

To determine the size of a foul air vent flue, first find out the number of pupils by allowing 225 cu. ft. of room contents to each pupil, then allow 16 sq. in. area in the flue to each pupil.

To determine the size of an aspirating radiator for a basement or first floor vent flue, allow ⅝ sq. ft. of radiation to each pupil; for a second floor vent flue, allow ⅞ sq. ft. to each pupil.

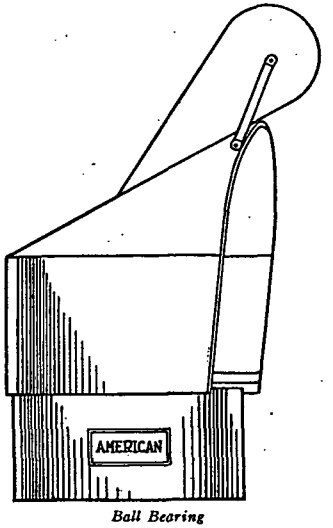
All vent flues should be connected to a collecting chamber or chambers constructed in attic. Size of chamber or chambers should be 10 per cent larger than the combined free area of all flues connecting into same.

Each collecting chamber should be connected to a revolving automatic ventilator. To determine the size of the ventilator, ½ sq. in. free area in ventilator should be allowed to each 1 sq. in. free area in foul air vent flues.

NOTE.—For positive ventilation and to insure the withdrawal of 30 cu. ft. of air per minute per pupil, we recommend the use of an exhaust fan in the attic, properly connected to all foul air vent flues.

Copyright 1928, C. C. SHIPP & COMPANY

AMERICAN AUTOMATIC VENTILATORS

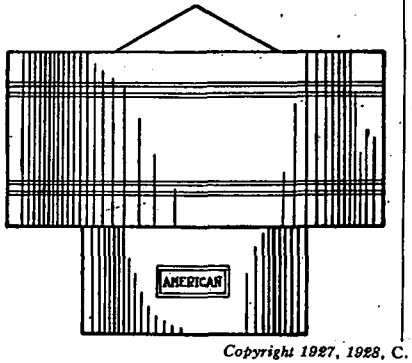


Ball Bearing

Diameter In.	Area in Sq. In.	Shipping Weight	Trade Price
10	78	20	$ 12.78
12	113	25	15.53
14	153	35	18.56
16	201	45	24.06
18	254	48	24.75
20	314	60	25.78
22	380	70	28.18
24	452	78	29.91
26	530	94	33.68
28	615	110	35.75
30	706	140	37.81
32	804	155	44.68
34	907	165	48.13
36	1017	197	50.88
38	1134	225	61.88
40	1256	250	68.75
42	1385	275	71.50
44	1520	300	78.38
46	1661	350	83.88
48	1809	378	89.38
50	1963	400	96.25
52	2123	425	103.13
54	2290	450	110.00
56	2463	500	119.63
58	2642	575	126.50
60	2827	660	134.75

NOTE.—Furnished in galvanized iron only unless otherwise ordered. Base extra.

AMERICAN STATIONARY VENTILATORS



Diameter In.	Area in Sq. In.	Shipping Weight	Trade Price
12	113	40	$ 3.92
14	153	50	5.63
16	201	60	8.66
18	254	70	10.65
20	314	90	13.75
24	380	100	17.18
30	706	150	23.38
36	1017	210	37.13
42	1385	350	49.50
48	1809	450	65.25
54	2290	570	75.63
60	2827	700	92.81

NOTE.—American Ventilators are received by all transportation companies under Classification One, double rate.

Copyright 1927, 1928, C. C. SHIPP & COMPANY

METHOD OF CALCULATION FOR D-I SANITARY VENTILATING RADIATOR UNITS

The following method of calculation for amount of air required is based on State requirements of Indiana, and will naturally vary in states where the requirements are different. However, the general principles of the method will apply to all cases.

1. The amount of Direct Radiation installed, which is not enclosed with the Air Diffusers, is that required for the exposed wall and glass. This Radiation is determined in the following manner:

2. Multiply square feet of glass surface in room by 89, if from zero to 70 deg., or by 99 if from −10 deg. to 70 deg.

3. Multiply the net wall by 27, if from zero to 70 deg., or by 37 if from −10 deg. to 70 deg.

4. Add results of 2 and 3, and divide by 250. This will give you the square feet of direct radiation necessary to overcome heat losses through glass and walls, which in the average school room is 120 to 140 sq. ft. Add 10 per cent to above figures for north or west exposures.

5. To determine the number of Wall Boxes required, first determine the number of pupils for the room. This can be obtained by dividing the cubical contents of the room by 225 (allowing 225 cu. ft. of contents per pupil).

6. Multiply the number of pupils by the amount of air required for each pupil per minute, which, for Indiana, is 30. This gives the total amount of the air required for the room per minute.

7. Divide the total amount of air required per minute by the capacity of the Wall Box to determine the number of boxes required.

8. *Example:* Assemble a room designed for 34 pupils; then, 34 × 30 (cu. ft. of air per minute per pupil) equals 1020 cu. ft. per minute; 1020 c.f.m. divided by 300 (capacity of 8 x 30 in. Wall Box) equals 3.4, or it will be necessary to use four 8 x 30 in. Wall Boxes.

9. Therefore, there will be required in the room four radiators, with a Wall Box for each radiator. Since, when using an 8 x 30 in. Wall Box, twelve sections of a Five Tube 38-in. radiator are enclosed by the air diffusers, there will be 60 sq. ft. of radiation enclosed in each radiator, or a total of 240 sq. ft. for ventilation.

10. To the preceding amount must be added the direct radiation required for wall and glass. Assume this to be 120 sq. ft. There would then be a total of 240 sq. ft. plus 120 sq. ft., making 360 sq. ft. in the room.

11. In designing the boiler, take special notice that the 240 sq. ft. of indirect radiation, or those sections enclosed in the Air Diffusers will condense two and one-half times as much steam as ordinary direct radiation. Therefore, the four radiators in the room will be equivalent to 2½ × 240 = 600 + 120, or a total of 720 sq. ft. of direct radiation.

12. If the building is an eight-room school house, it will require 8 × 720 plus whatever direct radiation there may be required in the halls, toilets, offices, etc.

13. Say there are 500 sq. ft. of radiation in the halls, etc. Then 8 × 720 = 5760 sq. ft.; 5760 sq. ft. + 500 sq. ft. = 6260 sq. ft.

The size of the boiler, together with the supply and return piping, should be based on an equivalent of 6260 sq. ft. of radiation, making due allowances for mains and risers.

We recommend, on account of better air distribution, the use of four Wall Boxes for the ordinary class room, the size depending, of course, upon the requirements.

Do not use radiation less than 26 in. high.

All Ventilating Radiators shall be arranged for supply and return connection at bottom on opposite ends.

All Ventilating Radiator Units used in connection with one pipe gravity steam system to be tapped as follows: 50 to 100 sq. ft. 1½ in. In no case should the Ventilating Radiator used in connection with the one pipe gravity steam system contain more than 100 sq. ft

All Ventilating Radiator Units used in connection with two pipe vacuum steam system tapped as follows, with supply and return connection at bottom of opposite ends:

60 to 90 sq. ft. 1 in. supply and ¾ in. return.

Above 90 sq. ft. 1¼ in. supply and ¾ in. return.

Each class room should be provided with a suitable foul air vent-flue, constructed on the opposite side of the room from the ventilating radiators. The size of this foul air vent-flue is based upon the number of pupils in the room. The State of Indiana requires 16 sq. in. in the foul air vent-flue for each pupil. Aspirating Radiators should be installed in each foul air vent-flue, allowing ⅝ sq. ft. per pupil on the first floor and ⅞ sq. ft. on the second floor.

All Foul Air Ventilating Flues should be connected to a foul air collecting chamber or chambers constructed in attic. The size of collecting chamber or chambers should be 10 per cent larger than the combined free area of all ventilating flues connecting into same. The foul air collecting chamber or chambers should be connected to a revolving automatic ventilator on the roof of the building of sufficient size and capacity to meet all requirements.

In determining size of American Automatic Ventilator one-half sq. in. free area in ventilator should be allowed to each one sq. in. of free area in foul air vent-flue.

Copyright 1917, 1919, 1923, 1926, 1927, 1928, C. C. Shipp & Company

Grinnell Company, Inc.

Heating, Industrial and Power Plant Piping, Fittings, Hangers, Valves, Pipe Bending, Welding, Piping Supplies, Etc.

Executive Offices: **Providence, R. I.**

Offices, Plants and Branches

Albany, N. Y.
Atlanta, Ga. (Plant and Foundry)
Auburn, R. I. (Plant and Foundry)
Baltimore, Md.
Boston, Mass.
Buffalo, N. Y.
Charlotte, N. C.
Chicago, Ill. (Branch)
Cincinnati, Ohio
Cleveland, Ohio (Branch)
Columbus, Ohio
Dallas, Texas
Denver, Colo.
Des Moines, Iowa
Detroit, Mich.
Hartford, Conn.
Indianapolis, Ind.
Kansas City, Mo.
Kearny, N. J. (Branch)
Milwaukee, Wis.
Minneapolis, Minn. (Branch)
Newark, N. J.
New Orleans, La.
New York, N. Y.
North Charlotte, N. C. (Branch)
Orlando, Fla.
Philadelphia, Penna. (Branch)
Providence, R. I. (Plant and Foundry)
Rochester, N. Y.
St. Louis, Mo.
Warren, Ohio (Plant and Foundry)

GRINNELL COMPANY OF THE PACIFIC

Los Angeles, Cal. (Branch) — Oakland, Cal. (Branch) — San Francisco, Cal. (Branch) — Seattle, Wash

GRINNELL COMPANY OF CANADA, LTD.

Montreal, Que. (Branch) — Vancouver, B. C. (Branch) — Toronto, Ont. (Plant and Foundry) — Winnipeg, Man.

PRODUCTS AND SERVICES—

Complete Service on materials to specification on Power Plant Piping, Industrial Piping, and Industrial Heating Systems; Fabricated piping including bends, welded headers, lap joints and the Grinnell Triple XXX line of products for Super Power; Grinnell Equiflo Valve; Grinnell Pipe Hangers and Fittings; Grinnell Thermolier (A new Development in Unit Heaters.)

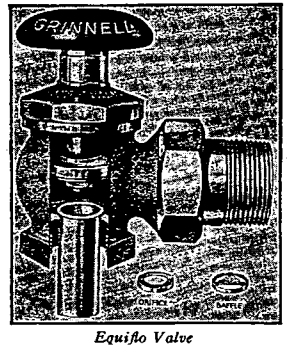
Also Humidifying systems; Constant Level Size Circulating System; Piping for acids and other special materials; Pipe Fabricating, Bending and Threading; Welding.

Brass, Bronze and other Castings; Valves: Air Relief, Globe, Angle, Cross, Check, Quick Opening and Closing. Non-return, Tank, Pressure, Reducing and Regulating, Safety and Y.

Pipe Bends and Coils; Unions, Tees, Ells and Nipples; Cast Iron, Steel and Wrought Iron Pipe; Pipe Rolls; Steam Traps.

Automatic Sprinkler Systems.

A Revolutionary Development in Forced Hot Water Heating—One of the chief difficulties in the way of a broader use of forced hot water heating systems with their many important advantages has been the determination of pipe sizes by the complex and arduous method of calculating frictional resistances. Failure to do this, plus easily possible installation mistakes has resulted in many unsatisfactory



Equiflo Valve

installations of this type of heating system.

This whole problem has now been simplified by the invention of the *Grinnell Equiflo Valve.*

The Grinnell Equiflo Valve for forced hot water heating *permits:*

1. The calculation of pipe sizes for this system by simple tables, similar to those commonly used in connection with the design of vacuum steam systems.

2. Change in locations of radiators or piping during installation to take care of local construction conditions without recalculation of pipe sizes.

The Grinnell Equiflo Valve for forced hot water heating *accomplishes:*

1. More nearly perfect equalization of flow to every radiator than has ever been

GRINNELL COMPANY

Heating, Industrial and Power Plant Piping, Fittings, Hangers, Valves, Pipe Bending, Welding, Piping Supplies, Etc.

practical by even the most careful calculation of pipe sizes. Size or location makes no difference.

2. The introduction of sufficient frictional resistance to completely overcome that trouble so pronounced in most forced hot water heating systems which is due to the well-known war between pump head (a constant) and the gravity or temperature head (a variable). This insures absolutely equalized circulation at all temperatures.

3. Lower pumping costs.

The Grinnell Equiflo Valve:

1. Serves as the regular shut-off valve for each radiator. It is of the packless type.

2. Is so designed that after the installation is completed a multiple-orifice cartridge or tube, having a definite resistance pre-determined by Grinnell Company, is dropped into place in the valve.

In order to obtain all the advantages of this new development, it is only necessary for the Consulting Engineer to specify that *each radiator shall be equipped with a Grinnell Equiflo Valve.* This device is marketed through the regular heating trade, and proper results are guaranteed by the standing of Grinnell Company in the hot water heating field.

Grinnell Triple (XXX) Products:

The growth and development of super-power demands a line of fabricated piping materials as definite and specific in its quality as the standardized manufactured products going into such work. Such a line is Grinnell Triple XXX. Due to its very nature, quality embraces design, manufacturing standards and workmanship.

Every item in this line has stamped on it three "X's" and underneath 40-60-90 representing 400, 600 or 900 lb. working steam pressure.

Any piece of material bearing that stamp can unhesitatingly be used for the pressures indicated.

All joints in the Grinnell Triple XXX line are machined out of a rough lap which may be forged to twice the thickness of the pipe or seamless tubing. A specially built lap joint machine, accomplishes this tremendous forging operation without changing the metal structure.

The basic idea of the Grinnell Triple XXX Pipe Joint is to provide absolute freedom in choosing the type of joint desired for varying conditions, and at the same time to assure maximum strength in the chosen type. The design provides ample thickness of metal in the rough forged lap allows for machining front and back for any conceivable face with a finished lap of 100 per cent strength.

The same manufacturing exactitude, coupled with a rigorous policy governing the selection of higher quality materials, produces bends and headers worthy with the lap joint henceforth to carry the mark of quality—XXX.

The production of this line necessitated the designing and building of one of the greatest lap joint machines in the world. This machine, plus a revision of manufacturing standards and processes, has resulted in a lap joint of unexcelled strength.

In addition to the line of individual products here noted Grinnell Company through its own Branches offers a complete service in pipe fabrication of every description. This includes pipe cut to sketch, pipe bends, welded headers, and miscellaneous piping supplies. Ample plant facilities enable us to give an unusual service in every part of the country.

Pipe Bends, Welds, Etc.—Grinnell facilities for making Pipe Bends, Welds and Lap Joints are second to none. Three plants—Warren, Ohio; Auburn, R. I.; Atlanta, Ga.,—equipped with special modern machinery and operated by the most skilful workmen make possible unusually prompt and efficient service on this important work.

Grinnell Fittings—After years of buying cast iron fittings on the open market Grinnell Company concluded that the best way to obtain clean accurate fittings of uniformly high quality was to cast them in Grinnell Foundries. Grinnell Cast Iron Flat Band Fittings made to conform to the American standard adopted by the Manufacturers Committee on Standardization of Fittings and by the N. F. P. A. can now be obtained by other users. Impartial purchasers agree that accuracy of threading, freedom from sand holes, and smoothness of core speed up installations and reduce replacements wherever Grinnell Fittings are specified.

APS
(Adjustable Pressed Steel)
CONCRETE INSERT

APS (adjustable pressed steel) Concrete Insert has many desirable features. Made from pressed steel, it is unusually strong with a large concrete holding surface. Although it comes completely assembled it has ample vertical and horizontal adjustment.

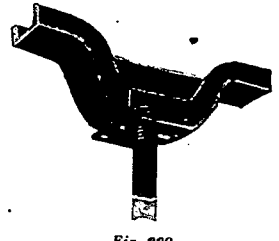


Fig. 229
APS Concrete Insert

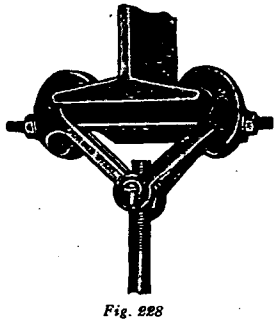


Fig. 228
UFS I-Beam Clamp

UFS
(Universal Forged Steel)
I-BEAM CLAMP

The UFS (Universal forged steel) I-Beam Clamp is the latest addition to the Grinnell Hanger line and is an outstanding development in convenience, strength and adjustability. While made only in three sizes, it covers the whole range of beam sizes from the smallest to Bethlehem 24-in. Forged steel construction gives to each size the same strength as the maximum rod strength involved. Rods carried range from 3/8 to 1½ in., providing for all pipe sizes up to 24 in.

Grinnell Company, Inc. Heating and Piping Systems

GRINNELL COMPANY

Heating, Industrial and Power Plant Piping, Fittings, Hangers, Valves, Pipe Bending, Welding, Piping Supplies, Etc.

GRINNELL COMPANY

Heating, Industrial and Power Plant Piping, Fittings, Hangers, Valves, Pipe Bending, Welding, Piping Supplies, Etc.

Grinnell Adjustable Pipe Hangers

ONE of the chief advantages of Grinnell Adjustable Hangers is that they permit adjustment of pipe lines after installation, thus obviating the necessity of turn buckles or the removal of hangers. And their time and trouble-saving qualities during installation are equally exceptional. On this and the following page are shown a few Grinnell Hangers of particular interest to heating engineers. The Grinnell Hanger Book, entitled "Safeguarding Heating and Service Pipe Lines," however, illustrates and describes the complete line. Engineers, Architects and Draftsmen will find a vast amount of useful information in this book.

Solid Ring—Adjustable Swivel Ring—Split Ring

(Patented October 4, 1921)



Fig. No. 101 Solid Ring

THIS Malleable Iron Adjustable Swivel Ring can be used with Coach Screw Rod or Machine Threaded Rod in connection with practically any type of Ceiling Flange, Expansion Case, Insert, etc.

With the Swivel Shank, an adjustment of at least 1½ in. is secured by turning the nut on the shank.

An unique locking device on the Swivel Shank automatically locks, preventing loosening due to vibration in the pipe line.



Fig. No. 104 Split Ring

The Split Ring Type has the same adjustment as in Fig. No. 101, either before or after the hinged section is bolted in place. The off-center hinging of the Ring provides sufficient seating to hold the pipe before closing the Ring. A wedge type Pin is loosely but inseparably cast into the hinged section for fastening this section after pipe is in place.

Universal Clamps

(Patented April 6, 1915)

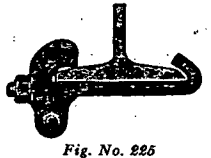


Fig. No. 225 Side I-Beam Clamp

THE Side I-Beam Clamp has ample strength for hanging ¾ to 12 in. pipe from I-Beams. Made in different sizes to fit all sizes of Standard and Bethlehem I-Beams, and most sizes of Bethlehem Girder Beams.

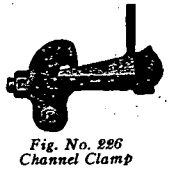


Fig. No. 226 Channel Clamp

The Grinnell Channel Clamp, made in three sizes with varying lengths of clamp rods, will meet most of the conditions encountered in practical installation work in connection with channels.

Adjustable Wall and Column Radiator Brackets

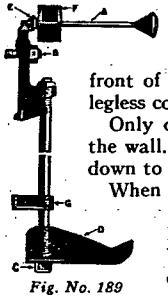


Fig. No. 189

THE bracket, Fig. 190, is designed to support a single tier of wall radiation. A similar bracket, No. 191, is designed to support a double tier, one in front of the other while the type Fig. 189, is designed to support legless column radiation.

Only one bolt is necessary to securely fasten these brackets to the wall. This means low installation cost and it cuts drilling holes down to a minimum.

When hook bolt is used, it can be set without extremely accurate measurements, due to the liberal range of vertical and horizontal adjustment, and as only three points of the bracket touch the wall, the difficulty so often experienced with rough brickwork is practically eliminated.

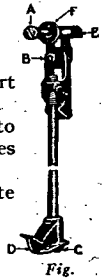


Fig. No. 190

GRINNELL COMPANY

Heating, Industrial and Power Plant Piping, Fittings, Hangers, Valves, Pipe Bending, Welding, Piping Supplies, Etc.

Adjustable Wall Coil Hangers

(Patented May 20, 1913)

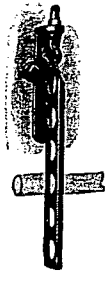


Fig. No. 160

THE Adjustable Wall Coil Hanger can be furnished with four separate brackets—two for single coils and two for double coils. The brackets locate the center of the coils 2¼ or 6¼ in. from back of bracket. Where double coils are used the second hangs 3½ in. in front of the first.

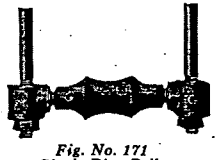


Fig. No. 171 Single Pipe Rolls

Single Pipe Rolls

GRINNELL Single Pipe Rolls are especially designed to take care of expansion and contraction. Rolls are made hollow which means small surface in contact with roll rod. The Adjustable Sockets permit vertical adjustment at the roll. The nut at the bottom of the hanger rod fits into a recess in the socket, thus preventing loosening or turning from vibration.

Adjustable Swivel Pipe Roll

(Patented October 4, 1921)

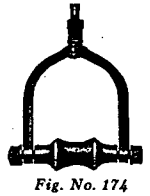


Fig. No. 174

THE Adjustable Swivel Pipe Roll supplies the need for any adjustable type of pipe roll hanger with single hanger rod. It is unique inasmuch as vertical adjustment can be made by use of the Swivel Shank at the top of the hanger.



Fig. No. 196

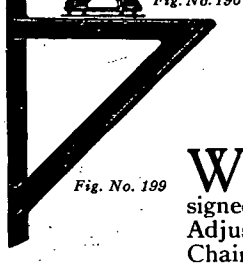


Fig. No. 199

Adjustable Pipe Stand— Anchor Chair— Pipe Seat—

WELDED STEEL BRACKET. Fig. 199 is light in weight and was designed primarily for use with the Grinnell Adjustable Pipe Stand Fig. 196, Anchor Chair Fig. 197 and Pipe Seat Fig. 198.

These combine the strongest type of brackets and pipe supports. The Adjustable Pipe Stand as used with the Steel Bracket has excellent adjustment features, it being possible to obtain both vertical and lateral adjustment.

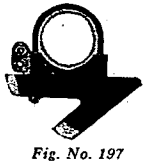


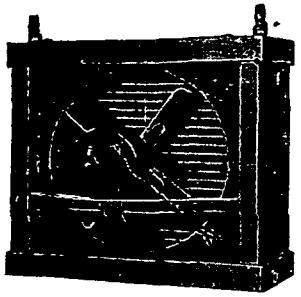
Fig. No. 197



Fig. No. 198

GRINNELL COMPANY

Heating, Industrial and Power Plant Piping, Fittings, Hangers, Valves, Pipe Bending, Welding, Piping Supplies, Etc.



Copper Housing Makes for Durability and Fine Appearance

Grinnell Thermolier

THE Grinnell Thermolier is a modern development of unit heaters. This principle of heating is rapidly becoming standard for use in many kinds of buildings. The reason for this may be briefly stated: (1) Low initial cost, (2) economy of operation, (3) adaptability, (4) maintenance, (5) depreciation.

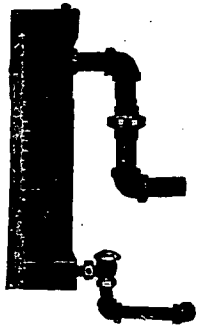
This unit is the result of two years' intensive investigation and test by the Grinnell organization which for 70 years has been recognized as a leader in industrial heating work. No pains have been spared to make it a most dependable, efficient and long-lived unit. Heat is obtained from brass-finned, seamless, copper U-tubes rolled into a cast-iron header. No solder is used for joints and there are no flat horizontal surfaces to catch dirt.

One model 800 Thermolier may be used to heat a floor area of 500 to 5000 sq. ft. Units may be controlled manually or automatically, singly or in groups.

Installation and piping are extremely simple and inexpensive, hence the unit may be moved from one location to another at small cost if found desirable on account of changes in building or occupancy. Furnished in several sizes for factory offices and small rooms.

Thermoliers provide excellent distribution of heat free from objectionable drafts. Model 800 furnishes from 160,000 to 230,000 B.t.u. per hour (depending on air temperature) on a 5-lb. steam pressure. May be used when desirable with steam pressures up to 125 lb.

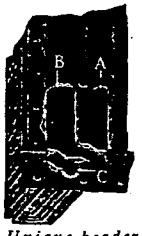
Specifications of Model 800.—Fan: Grinnell special of rugged construction. **Motor:** Heavy duty, oversize, enclosed, moisture-proof. **Housing:** Heavy copper, insuring exceptionally long life. Rubbed copper finish protected by high temperature lacquer. **Frame:** Heavy pressed steel, providing rugged support for motor and fan. **Special features:** Adjustable swivel hanger rod couplings; louvers rigid, but easily adjustable; integral cooling leg insuring complete drainage through one ¾-in. trap. For pressures not exceeding 50 lb., a thermostatic trap can be used and should be attached directly to unit.



Simple piping connections, both on same side, with close return trap

Particular attention is called to the integral cooling, a unique feature of the Thermolier which is of vast importance to the heating man. Due to the construction of the header in Thermolier, steam circulation and removal of condensation in this unit are distinctly different than is usual in such heaters.

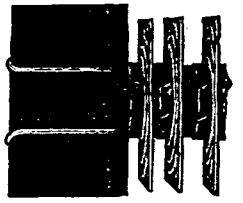
Steam is delivered into Chamber "A" of the header and circulates from there through the pitched U tubes, carrying its condensation with it into Chamber "B." By partitioning off the last two tubes at the bottom of the Steam Supply Chamber "A," these two tubes carry all condensation from Chamber "B" into Drain Chamber "C." In passage of this condensation through these two tubes, the air from the fan is rapidly carrying off heat just as it does in the rest of the unit. The result is that these two bottom tubes form an efficient internal cooling leg, integral with the unit. The actual cooling effect of this construction is equal to a run of more than 100 feet of the ordinary, exterior cooling leg piping.



Unique header construction forces all condensation through integral cooling leg

GRINNELL COMPANY

Heating, Industrial and Power Plant Piping, Fittings, Hangers, Valves, Pipe Bending, Welding, Piping Supplies, Etc.



Tubes expanded into cast-iron header

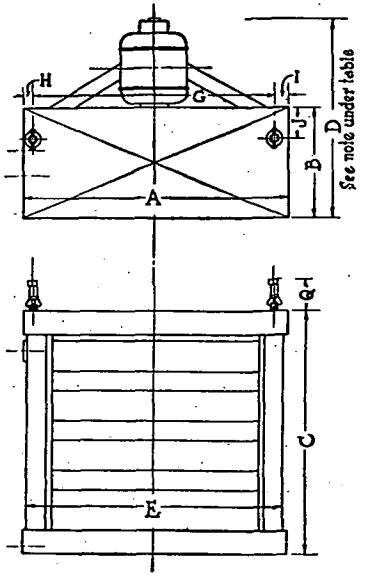
Due to the efficient functioning of the internal cooling leg, it is practical with the Grinnell Thermolier to make an exceedingly close connection of the return trap, as indicated on the drawing on previous page. The condensation coming from the unit is cool enough so that the trap will operate continuously even when the unit is working at maximum capacity for long periods. This feature, combined with the fact that the steam supply connection is at the same end of the unit, makes for compactness and neatness in the piping connections.

CAPACITIES—MODEL 800 WITH 1150 R.P.M. MOTOR

Equivalent Radiation at 60 deg. Entering Air Temperature (240 B.t.u. per Sq. Ft.) Equals 856 Sq. Ft.

Room Temperature at Inlet to Unit	5 Lbs. Steam Pressure	Room Temperature at Inlet to Unit	5 Lbs. Steam Pressure
40 deg. fahr.	232,000 B.t.u. per hour	80 deg. fahr.	180,000 B.t.u. per hour
50 deg. fahr.	218,500 B.t.u. per hour	90 deg. fahr.	167,000 B.t.u. per hour
60 deg. fahr.	205,500 B.t.u. per hour	100 deg. fahr.	154,000 B.t.u. per hour
70 deg. fahr.	193,000 B.t.u. per hour		

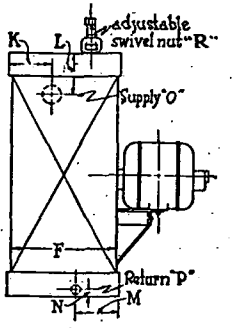
Data covering other sizes and capacities furnished on application.



Dimensions, Inches

A	27¾	J	3
B	11¾	K	4¾
C	25½	L	4¼
D	*21	M	4¾
E	27	N	¾
F	11	O	1½
G	25	P	¾
H	1⅛	Q	3⅛
I	1⅝	R	⅝

*Approximately, varies with different motors.



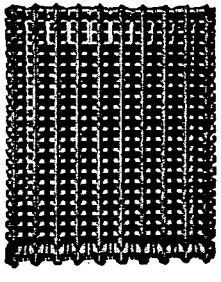
AMERICAN RADIATOR COMPANY

VENTO DIVISION

40 West 40th Street
New York City

816 S. Michigan Avenue
Chicago, Illinois

VENTO
Cast Iron Heaters



VENTO
Cast Iron Heater

Twenty-five years of successful operation of VENTO Heaters in thousands of installations in private and public buildings throughout America, Europe and Australia, disclose no failure of any kind.

VENTO has a unique construction which breaks up the air currents and assures rapid steam circulation, both of which features insure full heating efficiency of all the surfaces of the heater.

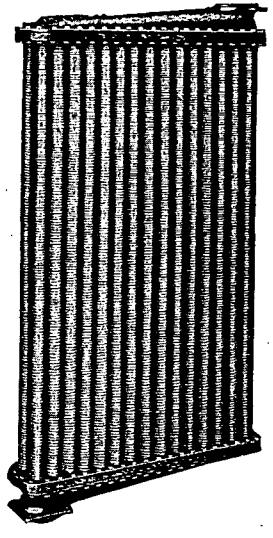
Being made up into stacks which are easily handled, and having far less joints per hundred square feet than pipe-coils, there is less liability to leaks. VENTO requires less labor to install, and calls for about 15 per cent less space. VENTO is made of cast iron, which does not rust by action of air, gases, water or summer dampness, and is much more durable than pipe-coils. VENTO Heaters do not freeze, split or corrode, nor is there any effect from electrolysis.

VENTO does not call for any new or special conditions in either housing or steam supply and drip connections. Both live and exhaust steam may be used at the same time.

In blast and plenum chamber work the *net installed* cost of VENTO is less than that of lighter forms of heaters.

A copy of the new revised edition of Engineer's Data on VENTO Heating will gladly be sent on request.

IDEAL ARCOBLAST HEATERS
For Unit Heater Work Only



IDEAL ARCOBLAST HEATER
For Unit Heater Work Only

The ARCOBLAST Heater, designed to meet the most exacting demands of the Heating Engineer, presents the following commendable features:

1. **Rugged Unit Design.**
2. **No soldered Steam-backed Joints.**
3. **Non-corrosive.**
4. **Ample Tube Steam Carrying Capacity.**
5. **Minimum Weight without Impairing Strength.**

The heater is composed of staggered rows of metallicly attached fin-wound copper tubes expanded into two cast iron tube sheets which, with the tapered design cast iron header bodies flange-connected to the tube sheets, form the supply and return headers.

The copper tubes are three-quarter inch outside diameter with a copper, helical-wound, flat, continuous fin three-eight inch in depth, metallicly attached to each tube. The materials of construction, copper for tubes and fin and cast iron for headers, offer a product which is non-corrosive.

A new Catalog containing complete technical data on IDEAL ARCOBLAST Heaters will be gladly sent on request.

40 West 40th St., **New York, N.Y.** 816 S. Michigan Ave., **Chicago, Ill.**

AEROFIN CORPORATION

850 Frelinghuysen Avenue
Newark, N.J.

Manufacturers of

AEROFIN

Standardized, Light-Weight, Fan System Heat-Surface

39 Cortlandt Street NEW YORK	Burnham Building CHICAGO	Paul Brown Building ST. LOUIS
Land Title Building PHILADELPHIA	Oliver Building PITTSBURGH	United Artists Building DETROIT

AEROFIN

AEROFIN is the modern standardized, light-weight Fan System Heat-Surface developed by Fan Engineers to meet the present-day requirements of this highly specialized field and to afford an adaptability which permits the new and advanced applications of tomorrow.

LOW PRESSURE AEROFIN, UNIVERSAL AEROFIN, HIGH PRESSURE AEROFIN

AEROFIN is built in three distinct types: LOW PRESSURE AEROFIN, tube-plate construction, for pressures up to 50 lbs. gauge; UNIVERSAL AEROFIN, continuous seamless tubes, multiple-coil construction, for pressures from 2½ to 150 lbs., gauge; and HIGH PRESSURE AEROFIN, continuous seamless tubes, for pressures from 25 to 350 lbs. gauge (Temp. 500° F.)

Design and Construction

The heat-transfer surface, in AEROFIN, is a plurality of seamless copper tubes about which is wound a helix of copper ribbon, crimped on its inner edge to permit winding and to afford maximum contact between tube and fin. The extended fin surface is applied, and tinned while held in position, by highly-developed automatic machines, being accurately crimped and spaced. The tinning of the tube and the extended surface makes them metallicly integral, affording maximum heat transmission and permanent effectiveness. The thickness and width (height) of the extended surface, the crimping and the pitch of the helix were determined by careful experiment, to afford maximum heat transfer, uniform air flow and minimum resistance thereto. The copper tubes and fins of AEROFIN transmit heat eight times as effectively as iron. So scientifically is AEROFIN designed that air is heated more in passage through a single row of its tubes, a travel of 1⅛ in., than in passage through an entire section of cast iron surface, a travel of 9 in.

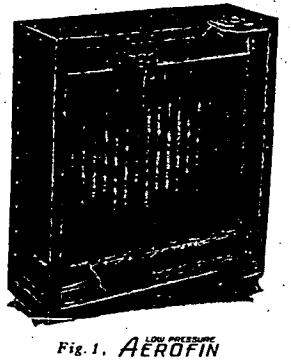


Fig. 1. LOW PRESSURE AEROFIN

In LOW PRESSURE AEROFIN the tubes are set into flexible tube-plates by means of a highly developed joint which is tight and permanent. See Fig. 1.

In UNIVERSAL AEROFIN and HIGH PRESSURE AEROFIN the seamless tubes, with their extended fin surface, are continuous. See Figs. 2 and 3.

Both LOW PRESSURE AEROFIN, UNIVERSAL AEROFIN and HIGH PRESSURE AEROFIN are furnished as completely encased units, ready for pipe and duct connections. The casings are built of pressed steel and are exceptionally strong and rigid, protecting the unit from all the strains of pipe connection and expansion or contraction in service. The casings are flanged on both faces, top and bottom, and template punched for bolting together adjacent units, or for duct connection.

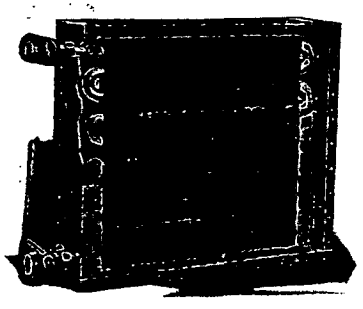


Fig. 2. HIGH PRESSURE AEROFIN

Standard Casings

The casings of all AEROFIN Units, whether comprising one, two or three rows of tubes, are **29 in. wide,** across tubes, from outer edge one flange to outer edge opposite flange, and **10 in. deep** in direction of air flow. **Length** of casing is nominal tube length plus 8½ in.

Sizes of LOW PRESSURE AEROFIN

LOW PRESSURE AEROFIN is made in fifteen standard tube lengths, either one, two or three staggered rows of tubes per Unit. There are thus forty-five standard Units available, a range which adequately meets all requirements.

Tubes are furnished of any length between 2 ft. 0 in. and 6 ft. 0 in., in increments of 6 in., and between 6 ft. 0 in. and 12 ft. 0 in. in increments of 1 ft.

Complete Tables of Sizes and Capacities are shown in our Bulletin G8, mailed gratis upon request.

Sizes of UNIVERSAL AEROFIN

UNIVERSAL AEROFIN is designed for installation with tubes horizontal only. It is available in one- or two-row Units, in seventeen standard nominal tube lengths (distance between end baffle plates, or between 180° bends,) between 2 ft. 0 in., and 10 ft. 0 in., inclusive, in increments of 6 in. Batteries of double width are easily assembled by setting Units end-to-end, leaving space for pipe connections.

In UNIVERSAL AEROFIN the seamless tubes are bent into a 3-pass coil, one end attached to the Supply Header, the other to the Drip Header, as indicated in Fig. 3. The connections to the welded Headers are made by means of special brass compression unions, insuring absolutely tight, dependable connections. (Tubes may be disconnected at unions and removed if, for any reason, this should become desirable.)

Complete Tables of Sizes and Capacities at various Pressures are shown in Bulletin GU-8.

Sizes of HIGH PRESSURE AEROFIN

HIGH PRESSURE AEROFIN is made in five standard tube lengths (i.e. length of straight section of tube, between the 180 deg. bends), 2 ft. 0 in., 2 ft. 6 in., 3 ft. 0 in., 3 ft. 6 in., 4 ft. 0 in., either one, two or three staggered rows of tubes per Unit. There are thus fifteen standard Units now available, meeting practically all requirements. Since the Supply and Drip Connections of HIGH PRESSURE AEROFIN are located on the same end, Fig. 2, Units may be placed end-to-end thus affording battery widths of twice the Standard tube-lengths. Complete Tables of Sizes and Capacities are shown in our Bulletin GHP-2, mailed gratis upon request.

Steel Supporting Legs

Standard Steel Supporting Legs, 18 in. or 24 in. high, template punched to same bolt hole centers as standard casing, are furnished when ordered. These legs may be attached quickly and obviate necessity of any other foundation.

Advantages

AEROFIN weighs but 9 to 16 per cent as much as equivalent cast iron, and occupies but 35 per cent of the space required by equivalent cast iron (3-row units). Two men can easily carry any AEROFIN Unit. Expensive foundations are unnecessary, building reenforcement is not required and the Units may readily be suspended from beams or roof trusses, or installed snugly in any out-of-the-way corner. The light weight and remarkable compactness of AEROFIN permit design heretofore impossible, bringing a new era in Fan Engineering,—enabling the Engineer or Architect to exercise his highest skill, undeterred by the weight and bulk which have limited him in the past.

The **encasing** of AEROFIN, complete, ready for pipe and duct connections, is the most important advance in Heating Surface since the inception of Fan Engineering. It avoids all the old familiar uncertainties and delays, insuring installation in the shortest possible time and at the lowest possible cost. Best of all, the cost of installing encased AEROFIN may be **calculated** with great accuracy. It isn't necessary to "guess at it" as of yore,—and probably discover that the "guess" was low enough to wipe out the profit on the job. The cost of installing AEROFIN is usually about one-fifth that for equivalent cast iron or "pipe-coil."

Whatever you've wished for in a Fan System Heating Surface you'll find in AEROFIN!

Publications

For complete Data on LOW PRESSURE AEROFIN ask for Bulletin G8, containing eighteen Piping Diagrams in four colors, representing the coordinated experience of the foremost Engineers in America.

Bulletin GU-8 affords complete data, on UNIVERSAL AEROFIN,—Sizes, Capacities, and 4-color Piping Diagrams.

Bulletin GHP-2 covers HIGH PRESSURE AEROFIN and contains large Temperature Effects Chart on linen.

Either or all Bulletins will be mailed promptly upon request to Newark.

Sales

AEROFIN is sold *only* by Manufacturers of nationally advertised Fan Heating Apparatus.

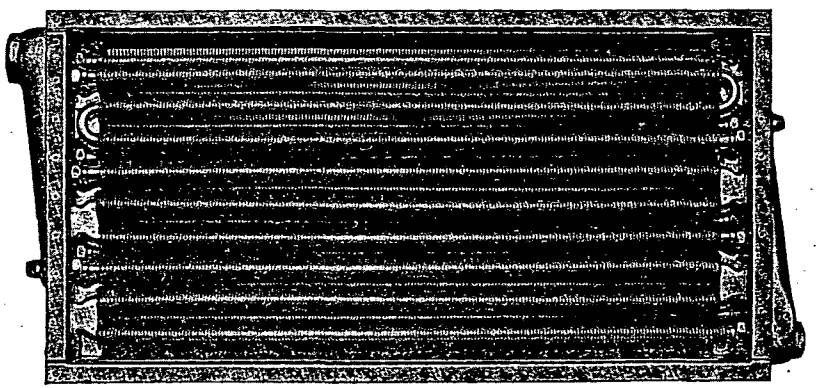


Fig. 3. UNIVERSAL AEROFIN—*End Baffle Plates and Upper Tube Clips removed to show construction*

McCord Radiator & Mfg. Co.

2587 E. Grand Boulevard **Detroit, Mich.**

Manufacturers of Spiral Fin-Tubing for Unit Heaters and Concealed Radiators, for Electric Refrigeration, Automotive Radiators and Metallic Asbestos Gaskets.

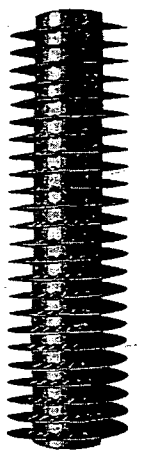
McCord tubing, now developed for use in heating and refrigeration systems, is the result of twenty-two years' experience in the building of automotive cooling systems.

The construction of McCord tubing insures a perfect contact between the fin and the tube, insuring greatest heat transfer. McCord solder was developed for the particular purpose of withstanding the high temperatures of heating requirements. The special "Spiral Fin-Tubing" is made by a patented process, and may be had in corrugated or plain fin.

It is made of seamless tubing, brass or copper, finished bright on inside. The corrugated or flat spiral fin is continuous with a perfect metal-to-metal contact between the fin and the tube which makes for efficient radiation. The tubing is made in either hard or soft temper and can be coiled on sort radius so as to occupy the minimum of space.

For heating purposes McCord Spiral Fin-Tubing is well adapted to unit heaters or concealed wall radiators, and is used by a number of manufacturers.

McCORD Spiral Fin-Tubing Compared on Basis of One Lineal Foot with Plain Tubing of the Same Outside Tube Diameter.



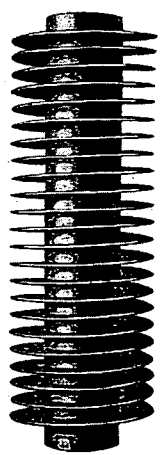
McCord Corrugated Spiral Fin-Tubing

Tube Size	Radiating Surface per Lineal Ft.	Heating Ratio
5/16"	McCord Spiral Fin-Tubing	= 70 sq. in.
5/16"	Plain Tubing	= 11 3/4 sq. in.
3/8"	McCord Spiral Fin-Tubing	= 113 sq. in.
3/8"	Plain Tubing	= 14 sq. in.
5/16"	McCord Spiral Fin-Tubing	= 122.5 sq. in.
5/16"	Plain Tubing	= 16.5 sq. in.
1/2"	McCord Spiral Fin-Tubing	= 132 sq. in.
1/2"	Plain Tubing	= 19 sq. in.
5/8"	McCord Spiral Fin-Tubing	= 150 3/4 sq. in.
5/8"	Plain Tubing	= 23 1/4 sq. in.
3/4"	McCord Spiral Tubing	= 229 sq. in.
3/4"	Plain Tubing	= 28 1/4 sq. in.
1"	McCord Spiral Tubing	= 375 sq. in.
1"	Plain Tubing	= 37 3/4 sq. in.

Sizes and Specifications

Tube Size	Width of Fin	Diameter McCord Spiral Fin-Tubing
1"	1/2"	2"
3/4"	3/8"	1 3/16"
5/8"	1/4"	1 1/8"
1/2"	1/4"	1"
7/16"	1/4"	15/16"
3/8"	1/4"	7/8"
5/16"	3/16"	11/16"

Standard lengths of tube up to 50 feet in copper or brass.
Standard gauge tube 0.028 wall. Special gauges on request.
Standard gauge fin 0.006 except 3/4 in. and 5/8 in. sizes. Flat Spiral Fin 0.012.



McCord Plain Spiral Flat Fin-Tubing

The Rome-Turney Radiator Co.

Rome, N. Y.

Exclusive Manufacturers of

ROME HELICALFIN COPPER RADIATION

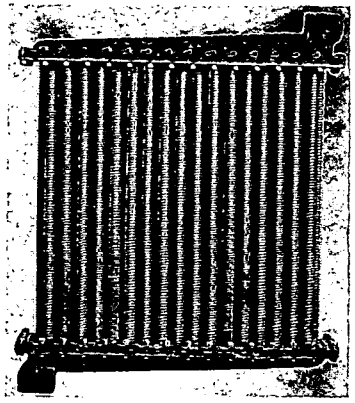
High Efficiency Extended Surface Type Blast Heaters, Unit Heaters, Radiators, Condensers, Coolers, Etc.

HELICALFIN Blast Heaters

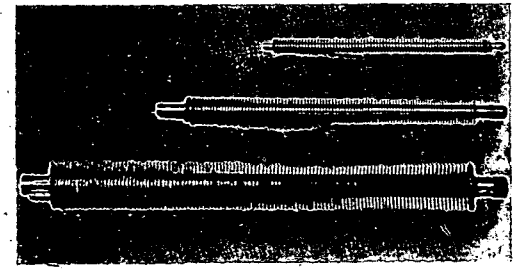
Standard Heaters constructed to meet the most rigid requirements of engineers and architects—Seamless copper tube construction with malleable iron headers. Complete range of sizes and capacities. Unusually sturdy and efficient. Engineering data on request.

HELICALFIN Heating and Cooling Tubes are made of the best grade of seamless copper tubing fitted with a continuous flat copper radiating fin.

They are supplied bent and formed for special installations requiring one-piece construction.



Rome Helicalfin Heater for Unit Heating Work



We make small sizes for refrigeration condensers, oil coolers and similar heat transfer work. 5/8, 3/4, 7/8 and 1 in. sizes for unit heaters and blast heating and ventilating systems.

Large sizes for direct radiation, car heaters, bathroom heaters and concealed residential and office heating. Made with ends threaded, ready for installation.

Rome HELICALFIN Products are sturdy, non-corrosive, highly efficient and as light in weight as is consistent with necessary strength.

For modern heating equipment in Schools, Factories and Homes,

specify

ROME HELICALFIN RADIATION

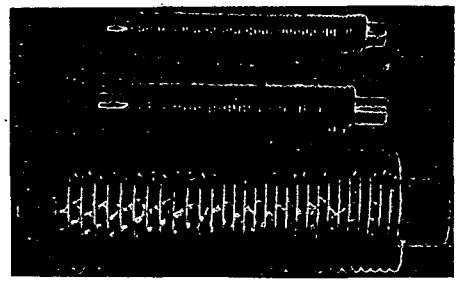
Good Radiators Since 1905

Schutte & Koerting Co.

1154 Thompson Street **Philadelphia, Pa.**

SCHUTTE KOERTING

RADIAFIN TUBES



for air-heating and air-cooling units

S&K Radiafin Tubes have from 7 to 16 times as much surface as plain tubes of the same size and length. This feature insures maximum heating or cooling capacity with minimum quantity of tubing and low initial and operating costs.

RADIAFIN TUBING AND PIPING DATA

Type of Tube or Pipe	Size of Tube or Pipe	Width of Fins	O. D. of Finned Tube or Pipe	Pitch of Fins	Ratio of Air Contact Surface to Water or Steam Contact Surface	Total Surface per Lineal Foot	Weight per Lineal Foot	Price per Lineal Foot	Price Flanges per Pair
Seamless Drawn Brass and Copper Tubing with Copper Fins. Pressures up to 250 lbs.	1/2"	1/4"	1"	1/7"	9.93 to 1	1.05 sq. ft.	0.357 lbs.		
	5/8"	1/4"	1 1/8"	1/7"	8.70 to 1	1.2 "	0.6 "		
	3/4"	5/16"	1 3/8"	1/6"	9.34 to 1	1.55 "	0.83 "		
	1"	3/8"	1 7/8"	1/5"	10.6 to 1	2.41 "	1.09 "		
	1 1/2"	3/8"	2 3/4"	1/4"	11.6 to 1	3.99 "	2.04 "		
Seamless Drawn Steel Tubing with Steel Fins. Pressures up to 250 lbs.	3/4"	1/2"	1 3/4"	3/8"	16.3 to 1	2.64 "	1.2 "	Prices on Application	
	1"	5/8"	2 1/4"	1/4"	14.75 to 1	3.22 "	1.93 "		
	1 1/4"	3/4"	2 3/4"	5/16"	13.72 to 1	3.80 "	2.80 "		
	1 1/2"	7/8"	3 1/4"	3/8"	13.0 to 1	4.35 "	4.4 "		
	2"	1 1/8"	4 1/4"	1/2"	12.0 to 1	5.52 "	6.1 "		
	3"	1 1/4"	5 1/2"	5/8"	9.17 to 1	6.55 "	10.5 "		
Seamless Drawn Brass and Copper Oval Tubing with Copper Fins. Pressures up to 250 lbs.	3/8"x1"	1/4"	5/8"x1 1/2"	1/7"	7.6 to 1	1.33 "	0.75 "		
Standard Steel Pipe with Steel Fins. Pressures up to 125 lbs.	3/8"	5/16"	1.3"	1/6"	11.6 to 1	1.5 "	1.03 "		
	1/2"	3/8"	1.59"	1/5"	10.9 to 1	1.78 "	1.41 "		
	3/4"	1/2"	2.05"	1/4"	11.1 to 1	2.41 "	1.95 "		
	1"	1/2"	2.56"	1/4"	13.5 to 1	3.7 "	2.9 "		
	1 1/4"	3/4"	3.16"	5/16"	12.2 to 1	4.4 "	4.02 "		
	1 1/2"	7/8"	3.65"	3/8"	12.1 to 1	5.1 "	5.75 "		
	2"	1 1/8"	4.62"	1/2"	11.2 to 1	6.07 "	8.2 "		
	2 1/2"	1 1/8"	5.12"	5/8"	9.47 to 1	6.12 "	9.54 "		
	3"	1 1/4"	6.0"	5/8"	8.97 to 1	7.2 "	13.77 "		
	4"	1 1/2"	7.5"	3/4"	8.6 to 1	9.05 "	20.89 "		
	6"	1 3/4"	10.12"	1"	6.7 to 1	10.64 "	31.07 "		

The S&K Radiafin Tubes and Pipes listed above can be furnished with plain or flanged ends and in any lengths up to 15 ft. Sold with or without headers.

D. & T. Manufacturing Company

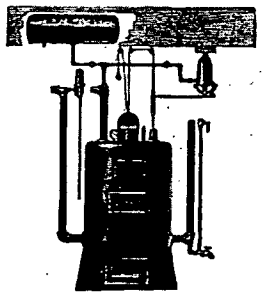
Factory and Engineering Dept.
3001-3009 La Salle Street
St. Louis, Mo.

General Sales Office
15-17 South Clinton Street
Chicago, Ill.

Pioneer Manufacturers
AUTOMATIC HOT WATER HEATING SPECIALTIES

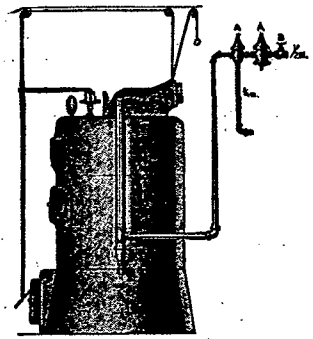
The Complete Line

D. & T. System



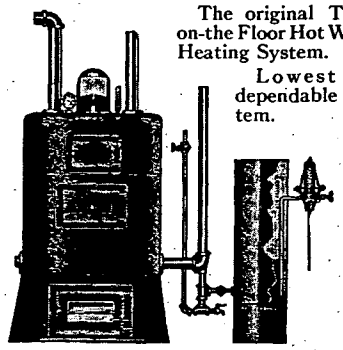
The original Tank-in-Basement Self-Regulated Hot Water Heating System. Economical, efficient and durable.

D. & T. Handy Regulator



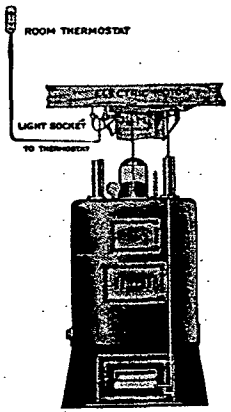
The D. & T. Handy Regulator automatically keeps the fire under perfect control.
All metal construction, no weights.

Simplex System



The original Tank-on-the Floor Hot Water Heating System.
Lowest cost dependable System.

J. M. Electric Temperature Regulator



A guaranteed Heat Regulator and fuel saver sold at a popular price.
Underwriters' Laboratories approved.

Combined Catalog and Text Book

The D. & T. "Progress in Hot Water Heating" Catalog in addition to listing, describing and illustrating our complete line of Automatic Systems and Specialties for Hot Water Heating also

Includes 50 Pages of Useful Data

design and standard practice detail, as substantiated and enthusiastically endorsed also by A. S. H. & V. E.

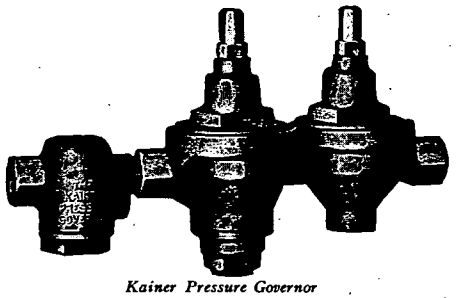
Write Today for Your Copy

Kainer & Company

761-771 Mather Street, **Chicago, Ill.**

THE KAINER PRESSURE GOVERNOR

(For Hot Water Heating Systems)



Kainer Pressure Governor

The Kainer Pressure Governor is a simple, safe and accurate device for pressure reducing and relief service on any hot water heating system. It is comprised of two automatic valve units (cast integral) and a filter. One valve unit reduces and governs the water supply; the other valve unit relieves the heating system when excessive pressure due to expansion develops.

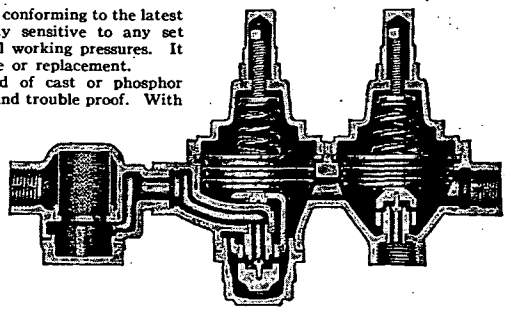
Full flow opening in the reducing unit permits of very quick filling of the system when first installed.

The filter is ruggedly constructed of heavy gauge perforated copper and is instantly accessible for cleaning.

The Kainer Bellows Diaphragm illustrated in the sectional view is used on both valve units. It is a very unique device conforming to the latest engineering practice. It is extremely sensitive to any set pressure and thoroughly tested for all working pressures. It contains no material requiring service or replacement.

The entire governor is constructed of cast or phosphor bronze, and is rust proof, scale proof and trouble proof. With very little effort it can be instantly taken apart for inspection and reassembled as quickly in the same manner.

The governor is tested at 60 pounds pressure and set at the factory to maintain 10 pounds on the system and to relieve the system when the pressure due to expansion reaches 30 pounds. Each valve unit has an adjustment screw concealed beneath a removable bonnet at the top of the valve permitting of a very quick and easy adjustment should a change of adjustment be desired.



Sectional View Illustrates the Kainer Bellows Diaphragm

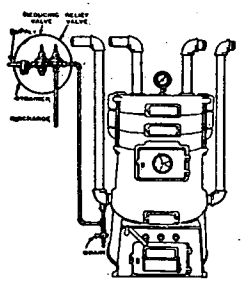
Extreme dimensions over all 10 in. wide, 5¾ in. high. Packed singly in cardboard cartons. Shipping weight approximately 5 pounds.

List price Kainer Pressure Governor, complete for mounting, **$24.00**

A typical installation of the Kainer Pressure Governor is shown on the diagram. It should be placed at the approximate height of the boiler—at the same time convenient for inspection—and connected to the return main. The filter and reducing unit are connected to water supply and the relief unit to the return main. A connection should run from the relief unit to floor drain.

The water that may pass through the relief unit is automatically replaced with fresh water when the pressure on the system is reduced to below that at which the valve is set.

A pressure gauge should be used on the boiler. 30 pounds is considered a safe maximum pressure on most boilers and the gauge should never show much above that if relief valve is set to relieve at that pressure.



Installation Diagram

Kainer Sylphon Hot Water Damper Regulator

Information furnished on request. Complete for mounting, **$16.00**

Kainer Pressure Gauge

Complete for mounting. Prices on application.

MUELLER CO.

Decatur, Ill.

BRANCHES

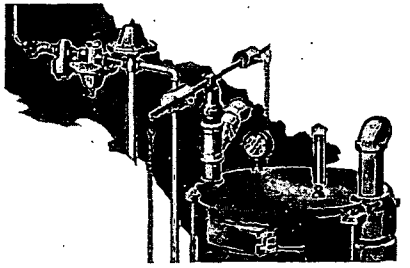
E. 135th St. and Walnut Ave., Bronx, New York 1072-76 Howard St., San Francisco 2468 Hunter St., Los Angeles
901 McKinney St., Dallas, Texas

PRODUCTS

Mueller Automatic System of Hot Water Heat Control

Reducing and Regulating Valves for water.
Reducing and Regulating Valves for steam.
Relief Valves. Water Strainers.

Complete line of High Grade Plumbing Brass Goods



Mueller Automatic System of Hot Water Heat Control—This is a closed system operating automatically without an expansion tank. It can be quickly installed on either new or old jobs.

The water in the system is always kept fresh. This promotes good circulation. Just enough water is admitted by the reducing valve to supply the amount released by the relief valve.

A very considerable saving in fuel is effected due to the automatic control of dampers and rapid circulation.

Perfectly safe as both reducing valve and relief valve are operated by the pressure of the water in the system. These valves are especially constructed and tested for use on this system.

The reducing and relief valves are positive in action and durable, the working parts being made of bronze with phosphor bronze diaphragms.

Boiling point of water raised to higher point than with open system.

The damper regulator is a very important part of this system as it is not only a fuel saver but also is a safety feature, checking the fire when the desired temperature is reached.

The Mueller System can be readily used with a thermostatic control, operated by a motor in the basement. Mueller positive control of pressure in the system assures permanent safety.

Reducing and Regulating Valves—For steam, water, air, gas, oil, etc. All are diaphragm operated and positive in action. Their reputation for sustained accuracy is known wherever regulating valves are used.

Brass Goods—Everything in the line of brass faucets, stops, etc., for lavatory and bath room, and also complete line of laboratory faucets adopted and approved by leading universities such as the Massachusetts Tech.

Relief Valves—Mueller Relief Valves are absolutely dependable. They have been approved by the National Board of Boiler and Pressure Vessel inspectors and correspond to the code of the American Society of Mechanical Engineers. Tests in the Underwriters' Laboratories have proved the Mueller Relief Valve safe.

Mueller Co. has been in business from 1857 and has an acknowledged reputation for quality goods.

Specific information regarding any Mueller product will be cheerfully given upon request.

Neptune Meter Company

50 East 42nd Street **New York, N. Y.**

Branch Offices

ATLANTA, GA.	1172 Virginia Avenue	LOS ANGELES, CALIF.	701 E. Third Street
BOSTON, MASS.	141 Milk Street	PORTLAND, ORE.	474 Glisan Street
CHICAGO, ILL.	130 N. Jefferson Street	SAN FRANCISCO, CALIF.	320 Market Street
DENVER, COLO.	1700 15th Street	ST. LOUIS, MO.	1912 Pine Street

NEPTUNE METER CO., LTD., 345 Sorauren Avenue, Toronto, Ont.

PRODUCTS—Red Top Relief Valve, Model No. 2, the basis of your own closed hot water heating system, and for protecting hot water heating systems against boiler explosions, cracked boiler sections, and other ruptures.

Red Top Relief Valve, Model No. 1, for protecting range boilers, tank heaters, piping and fixtures in domestic hot water supply systems against dangerous pressures.

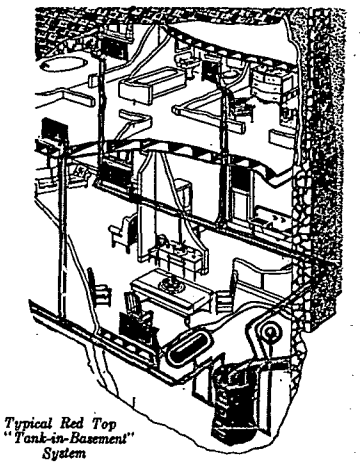
Red Top "Tank-in-Basement" (or Pressure System) of Hot Water Heating

A No. 2 Red Top Relief Valve, and *any air-tight tank of good make* are the *only two special parts* required for the most efficient, low-cost system of hot water heating.

The illustration shows a typical Red Top System in a two story residence. The air-tight tank—which gives a cushioning effect that promotes rapid circulation—is placed in the basement where it belongs. Since the hot water circulation is more rapid, smaller piping and less radiation surface may be used.

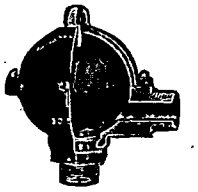
For a "closed" system the following sizes of air-tight expansion tank are suggested:

Up to	500 ft. rad.,	15 gal. tank	12 in. diam. x 30 in. long
500 to	800 ft. rad.,	21 gal. tank	12 in. diam. x 42 in. long
800 to	1200 ft. rad.,	26 gal. tank	12 in. diam. x 54 in. long
1200 to	1600 ft. rad.,	42 gal. tank	___ diam. ___ long



Typical Red Top "Tank-in-Basement" System

Red Top "Tank-in-Basement" Systems Offer These Advantages:



Sectional View, Model No. 2, Red Top Relief Valve

1. No more cracked boiler sections or other costly ruptures due to excessive pressures.
2. No more frozen overflow pipes, or corroded and clogged expansion tank outlets.
3. More efficient heating due to faster circulation of hot water—twice as fast as in old type overhead gravity systems.
4. Water, returning to the boiler at a higher temperature, requires less reheating.
5. Fuel is saved—frequently as much as 20%.
6. Less firing—saving labor.
7. Expansion tank is in basement. It does not take up usable space in some other part of house.
8. No waste of water from system. No water can leave until the pressure reaches the danger point, when water is automatically released by the Red Top Relief Valve.
9. Very moderate in cost. Easily applied when the heating plant is installed.
10. Old systems can be changed over to the Red Top with little trouble and small cost.
11. First, last and *always* a *safe* system—protecting property and life from dangerous rising pressures.

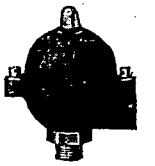
Approved by Underwriters

Red Top Relief Valves, both Model No. 1 and No. 2, are approved by the Underwriters' Laboratories, and by state and municipal bureaus of water and boiler inspection.

Red Top Relief Valves act on the dead weight or gravity principle. In Model No. 2, a special nickel weighted piston is lifted off its seat when pressure reaches 30 lb. Non-corrosive metal is used throughout. No springs, levers, diaphragms or other complicated parts to get out of order. Made for either "open" or "closed" systems. Model No. 2 is 6½ in. high, 5¾ in. wide, with inlet and male outlet threaded for standard 1 in. fittings.

Model No. 1 For Domestic Hot Water Supply

Protects domestic hot water supply and prevents range boiler explosions and other ruptures. Made with inlet threaded for standard ½ in. pipe fitting and outlet drilled and tapped for ½ in. connection. May be adjusted to relieve automatically at 50, 75, 100 and 130 lb. pressure. Model No. 1 is 4½ in. high and 4 in. wide.



Model No. 1, Red Top Relief Valve

Thrush Differential Pressure Relief

H. A. Thrush & Company

Makers of Thrush System

Factory and Offices

Peru, Ind.

Thrush Automatic Damper Regulator

Thrush System comprises equipment to be added to any unregulated gravity hot water heating plant to make it a "Closed System" operating under slight added pressure and with automatic control of dampers.

Thrush Differential Pressure Relief Valve

A large flexible diaphragm which places a thrust against the Valve member making it certain that the Valve will open. Valve seat is at all times submerged in water, won't corrode because it has no contact with atmosphere. Dirt and sediment will not collect at the valve seat. Design is such that heavier solids fall away from seat. Regularly set to open at 26 lb. pressure for 1, 2 and 3 story buildings. For higher buildings, adjustments made at factory. Non-adjustable and not easily tampered with. No small restricted openings.

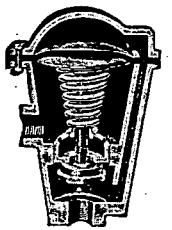


Fig. 1



Fig. 4

THRUSH THERMOMETER and SPECIAL GAUGE furnished with **Thrush System** simplify operation.



Fig. 5

Benefits of Thrush System of Hot Water Heating

Thrush Pressure System actually increases rate of heat transmission,—faster circulation and hotter radiators. Therefore lower water temperatures may be carried.

Installation is easy, requiring but 6 ft. of ¾ in. pipe and eight fittings. A further reduction of pipe sizes makes for lower cost and higher efficiency.

Thrush Automatic Temperature Damper Regulator

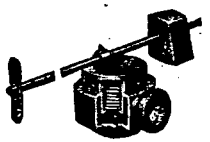


Fig. 2

Its operation depends upon the temperature change of the water circulating through the heating system and not upon pressure. Maintains different water temperatures by simple adjustment of sliding weights on lever. Multiple disc thermostat sets in dry well permitting easy inspection. A fuel saver. Easily connected with one short nipple as shown in Fig. 6.

Thrush Pressure Tank



Fig. 3 Thrush Pressure Tank

Serves two purposes—conserves hot water and returns it to system—and being closed to the air, it maintains pressure on the system by compression and expansion of the air in the tank. **Thrush tanks** are made of copper bearing steel, welded and tested, coated with enamel. Connect as shown in Fig. 6.

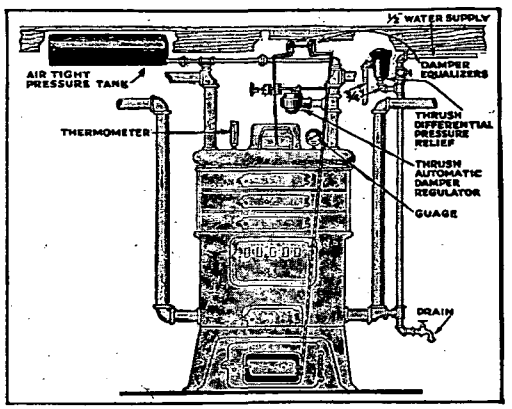


Fig. 6

DATA AND SPECIFICATIONS

CLASS "A" EQUIPMENT

Consists of *Thrush Automatic Temperature Damper Regulator, Differential Pressure Relief, Air Tight Pressure Tank, Special Gauge and Thermometer.*

CLASS "B" EQUIPMENT

Consists of *Thrush Differential Pressure Relief, Air Tight Pressure Tank, Special Gauge and Thermometer.*

SIZES

Size No. 0 up to 350 sq. ft. of radiation
Size No. 1 up to 750 sq. ft. of radiation
Size No. 2 up to 1250 sq. ft. of radiation
Size No. 3 up to 2000 sq. ft. of radiation

For larger job use additional pressure tanks of proper capacity

Consolidated Ashcroft Hancock Co., Inc.
American Schaeffer & Budenberg Division

338 Berry Street **Brooklyn, N.Y.**

BRANCHES IN PRINCIPAL CITIES

Manufacturers of Indicating and Recording Gauges; Gauge Testers; "U" Gauges; Draft Gauges; Indicating and Recording Thermometers; Tachometers; Dial Thermometers; Pressure and Temperature Controllers; Electric Temperature Controllers; Pop Safety and Water Relief Valves; Steam Traps; Engine Indicators; Counters; Absolute Pressure Gauges.

Also manufacturers of Locomotive and Engine Room Clocks; Barometers; Mercury Column Gauges; Steam Whistles; Hydraulagraphs; Gauge Boards.

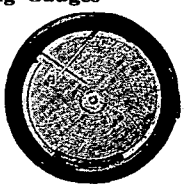
American Quality Gauges



American Quality Gauges are made in all sizes from 2½ to 12 in., for pressures from 10 to 30,000 lb. and also for vacuum. Cases are cast iron or cast brass. The movements are Heavy Duty and all bearings are Monel Metal. Write for Catalog No. A-59.

For Mercury Pressure and Vacuum Gauges, "U" Gauges, Draft Gauges and Mercurial Barometers, write for Catalog No. B-59.

American Recording Gauges



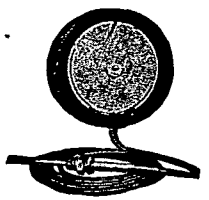
American Recording Gauges are made for all pressures from 15 in. of water to 10,000 lb. and for vacuum. They are made in one size only to accommodate a 10 in. chart, having an effective scale width of 3⅝ in. The case is Die Cast with a dull black hard-rubber finish and with either bottom or back connection. The pen-arm is made of non-corrosive Monel Metal and is of the inverted type. Operating instructions are lithographed on the chart plate so that they cannot be lost.

Especially designed Seth Thomas clocks are used, and all customary time periods can be furnished.

American Recording Gauges are equipped with the Time Punch which virtually makes each instrument a time clock, since a hole is punched in the chart whenever a reading is taken.

Write for Catalog E-59.

American Recording Thermometers

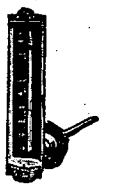


American Recording Thermometers are made for recording all temperatures from minus 40 to plus 1000° F. or equivalent C, and with very flexible connecting tubing up to 200 ft. Made in one size only to accommodate 10 in. chart, with any effective scale width of 3⅝ in.

The case is the same as for the American Recording Gauge, so that all instruments are uniform in appearance when mounted on Gauge Boards. American Indicating Gauges and Dial Thermometers are also furnished in same case.

Write for Catalog H-59.

American Air Duct Thermometer



Designed especially for both warm and cold air ducts. Fitted with polished brass or nickel plated "V" shaped case, glass front. Furnished with 9-in. or 12-in. scale graduated 0-160° F.

Write for Catalog F-59.

American Dial Thermometers



American Dial (mercury-filled) Indicating Thermometer has the accuracy of the standard glass tube thermometer and the reading convenience of a dial face. Entire working mechanism is made of steel, meaning long life.

Standard size of dial 6 and 12 in. Furnished with either rigid connection or flexible capillary steel tubing up to 200 ft. long. Made for any temperature range from minus 40 to plus 1000° F.

Write for Catalog G-59.

American Automatic Controllers

A complete line of American Controllers for automatically controlling pressure, vacuum, temperature, condensation, humidity liquid levels, timing of processes, control of dampers, etc.

Write for Catalog R-59.

American Pop Safety and Water Relief Valves

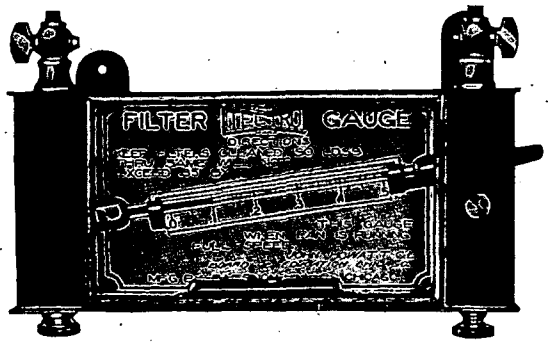


Safety Valves of brass and iron for any set pressure up to 300 lb., and of cast steel with outside spring up to 400 lb. Relief Valves of bronze and iron for pressures up to 10,000 lb.

Write for Catalogs U-59 and V-59.

VERNON HILL
AEROLOGISTS

121 North Clark Street — **Chicago, Ill.**



TELTRU FILTER GAUGE

A New Product

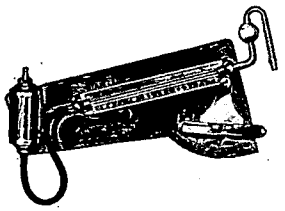
that has every desirable feature of other gauges, and several new ones.

An **unbreakable glass** front.

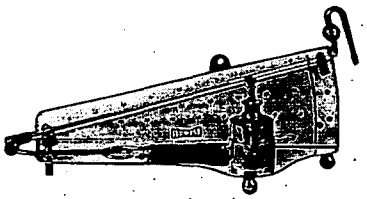
Removable and replaceable gauge glass.

All parts accessible by the removal of one thumb screw.

A display card back of the scale, bearing the filter manufacturer's name and *his* directions.



TELTRU SLANT GAUGE
for chimney draft determinations. Complete with static tip and carrying case.



TELTRU PITOT TUBE GAUGE
The standard portable gauge and tube outfit for general air velocity determinations.

Write for descriptive circulars of other gauges and air testing instruments

No obligation

TELTRU

A TRADE MARK WITH A MEANING

Taylor Instrument Companies

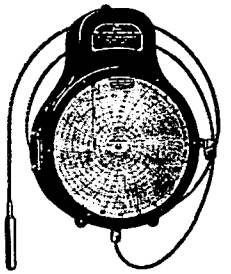
Rochester, N. Y., U. S. A.

CANADIAN PLANT, Tycos Building, Toronto, Canada

NEW YORK	PHILADELPHIA	LOS ANGELES	ST. LOUIS	DETROIT
CHICAGO	PITTSBURGH	INDIANAPOLIS	CINCINNATI	ATLANTA
BOSTON	CLEVELAND	SAN FRANCISCO	TULSA	MINNEAPOLIS

Manufacturing Distributors in Great Britain, Short & Mason, Ltd., London

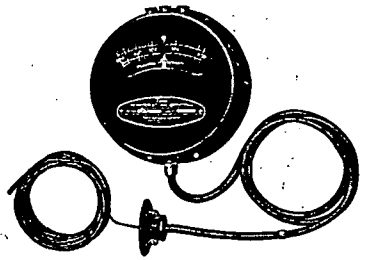
Manufacturers of Tycos Instruments for Indicating, Recording and Controlling Temperature, Pressure and Humidity



Tycos Suspended-Pen Recorders

Temperature ranges and time requirements vary greatly in heating and ventilating work. Tycos Suspended-Pen Recorders are made in many scale ranges and several time periods to meet these needs. Tycos Recorders are sturdy and reliable. The friction of moving parts has been reduced to a minimum. Charts are easily changed, and each instrument is locked and sealed against malicious or unintentional interference with the mechanism. Cases are handsomely finished and are dust and moisture proof. Instruments may be quickly tested and calibrated. Write for special information suitable to your needs.

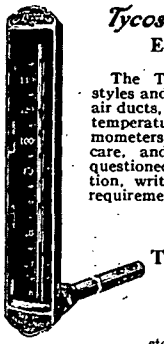
Tycos Electric Contact Temperature Control



These instruments combine in the same case an electrically-operated temperature regulator with an indicating thermometer. One tube system only is required to operate both units.

Direct-Set Control Feature: This feature has been developed in Tycos Electric-Contact Controls until we believe that no similar instrument on the market can compare with it for convenience and accuracy. The Tycos Direct-Setting Feature is a real time saver, because it eliminates making a series of adjustments in order to obtain the proper control. Only one adjustment is required.

The instrument will control at this point within the limits of its contact until re-set for another temperature.

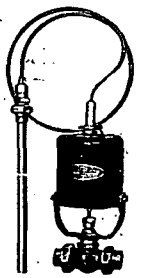


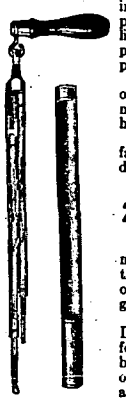
Tycos Thermometers for Enclosed Spaces

The Tycos line presents many styles and scale ranges. Suitable for air ducts, kiln temperatures and oven temperatures. Tycos Industrial Thermometers are made with the greatest care, and their reliability is unquestioned. For detailed information, write direct, mentioning your requirements.

The *Tycos* Self-Acting Temperature Regulator

Is adapted to use on hot-water storage tanks, etc. It is "self-acting" in that it requires no auxiliary motive power, such as compressed air, to open and close the steam valve. As heat is applied to the bulb the volatile liquid inside sets up a vapor pressure proportional to the temperature. This pressure is transmitted to a "stack" of metal diaphragms attached to the upper end of the valve stem, thus moving the valve disc toward the valve seat. By means of the adjustment at the top of the diaphragm housing, the valve can be closed at any desired temperature, or a throttling action can be obtained within the temperature range of the instrument. Not practicable on pipe lines having steam pressure over 125 pounds.





Should be installed in a vertical position on top of the line; never hanging underneath the line. The line itself should be horizontal rather than vertical.

Operating range 100 deg. to 160 deg. fahr., 140 deg. to 212 deg. fahr., or 190 deg. to 270 deg. fahr., as specified.

Tycos Sling Psychrometer

The Tycos Sling Psychrometer is a modification of the pattern developed by the U. S. Weather Bureau. The fact that our design has been generally copied is good evidence of its practicable features.

The advantage of this form of Wet-and-Dry-Bulb Hygrometer over the stationary form is the facility with which tests can be made and the accuracy of the readings obtainable, as in whirling the bulbs they are subjected to perfect circulation.

Johns-Manville Corporation

Miners of Asbestos, Manufacturers of Asbestos and Allied Products

EXECUTIVE OFFICES

292 Madison Avenue, at 41st Street - NEW YORK, N. Y.

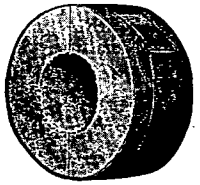
Branches in all large cities

DIVISION SALES OFFICES

CHICAGO, ILL., Michigan Avenue at 18th Street
CLEVELAND, OHIO, 6300 Euclid Avenue
NEW YORK, N. Y., 292 Madison Avenue at 41st Street (Executive Offices)
SAN FRANCISCO, CAL., 159 New Montgomery St.
TORONTO, ONT., Canadian Johns-Manville Co., Ltd., 19 Front Street, East

Please Communicate with Nearest Division Sales Office

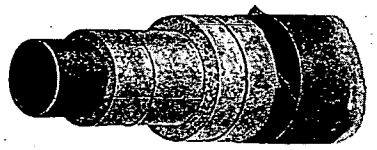
INSULATION SPECIFICATIONS
(Abbreviated Form)



Johns-Manville 85% Magnesia

High Pressure and Intermediate Pressure Steam Lines—All high pressure and intermediate pressure steam lines indoors, and high pressure drip piping, including connections to all engines, turbines, pumps, auxiliaries, water columns, safety valves, superheaters and soot blowers, shall be insulated with Johns-Manville 85% Magnesia of the following thickness:

Steam Pressure or Condition	Temperature Deg. Fahr.	Thickness of Insulation: Pipes Larger than 4 in.	Pipes 2 in. to 4 in.	Pipes Smaller than 2 in.
25 to 100 lbs.	267 to 338	1½"	Std.	Std.
100 to 200 lbs.	338 to 388	2"	1½"	Std.
Low Superheat	388 to 500	Dbl. Std.	2"	1½"
Superheat	500 to 600	3"	Dbl. Std.	2"

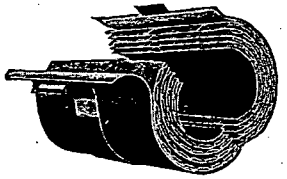


Johns-Manville Superex Combination Insulation

Superheated Steam Piping (Temperatures above 600 deg. fahr.)—All superheated steam piping shall be insulated with Johns-Manville Superex Combination Insulation. Superex and 85% Magnesia of thickness shown below:

Steam Condition	Temperature, Deg. Fahr.	Thickness of Insulation: Pipes 2" 2½" 3½" Superex	85% Mag.	Pipes 3" and 4" Superex	85% Mag.	Pipes 4½". Superex	85% Mag.	Pipes 5" and larger Superex	85% Mag.
High Superheat	600 to 700	1¼	1½	1½	1½	1¼	2	1½	2
	700 to 800	1¼	2	1½	2	1¼	2½	1½	2½

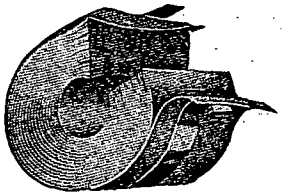
Single layer 2" Superex Insulation on lines 1½ inch and smaller.



Johns-Manville Improved Asbestocel Insulation

Low Pressure and Exhaust Steam and Feed Water Piping—All low pressure, exhaust steam and feed water piping shall be insulated with 4-ply Johns-Manville Improved Asbestocel Sectional Insulation.

Steam Heating Supply and Return Mains, Risers and Radiator Branches—All steam heating supply and return mains and branches, and all risers, shall be insulated with 4-ply Johns-Manville Improved Asbestocel Insulation. All concealed radiator branches shall be insulated with 3-ply Johns-Manville Improved Asbestocel Insulation.

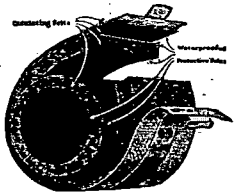


Johns-Manville Asbesto-Sponge Felted Insulation

High Pressure Steam Lines in Manufacturing Buildings—All high pressure steam piping and high pressure drip piping used in connection with distribution of steam for manufacturing purposes shall be insulated with Asbesto-Sponge Felted Sectional Insulation of the following thicknesses:

Steam Pressure or Condition	Temperature Deg. Fahr.	Thickness of Insulation: Pipes Larger than 4 in.	Pipes 2 in. to 4 in.	Pipes Smaller than 2 in.
0 to 25 lb.	212 to 267	1"	1"	1"
25 to 100 lb.	267 to 338	1½"	1½"	1"
100 to 200 lb.	338 to 388	2"	1½"	1"
Low Superheat	388 to 500	2½"	2"	1½"
Superheat	500 to 600	3"	2½"	2"
High Superheat	600 to 700	3½"	3"	2"

Fittings, Valves and Flanges—All pipe fittings, valves and flanges shall be insulated with block and plastic insulation to the same thickness as the adjacent pipe insulation. Block insulation shall be of the same material as the adjacent pipe insulation and plastic material used shall be hard finish Asbestos Cement. Block insulation may be omitted on pipe sizes smaller than 4 in., or where total thickness of insulation is less than 1½ in. and the entire thickness of insulation in such cases may be made up of hard finish Asbestos Cement.

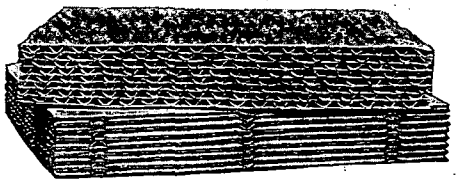


Johns-Manville Anti-Sweat Insulation

Cold Water Piping—All cold service water piping, including risers and concealed fixture connections or exposed soil or waste lines, shall be insulated with Anti-Sweat Insulation 1 in. thick applied in two layers with all joints broken, fittings with Hair Felt and hard finish Asbestos Cement to the same thickness.

Finish of Insulation—All insulation on pipes, fittings, valves and flanges which is exposed to view shall be enclosed in an extra jacket of 8-oz. canvas sewed over rosin sized paper.

Where insulation is concealed the light canvas furnished in manufacture is to be pasted down over the joints and the insulation additionally secured by means of brass lacquered bands applied at least two to a section.



Johns-Manville Asbestocel Sheet

Warm Air Ducts—All warm air ducts, flues, heater casings and fan housings in the ventilating system shall be insulated with 4-ply Improved Asbestocel sheet insulation finished with hard finish Asbestos Cement ½ inch thick, applied over hexagonal wire reinforcement. The cement finish shall be troweled to a smooth and uniform surface. Where this insulation is exposed to view it shall be finished with a jacket of 8-oz. canvas, glued to the insulation and sewed in place.

Painting—All insulation exposed to view and enclosed in a jacket of 8-oz. canvas is to be painted with one coat of glue sizing and two coats of first quality lead and oil paint of a color selected by the architect.

Underground Lines—All high and low pressure steam lines and hot water lines running under ground outside of buildings shall be installed in Johns-Manville System of Underground Insulation. This system shall be installed in accordance with the manufacturer's specifications.

All of the above insulation is to be furnished and applied by the manufacturer of the materials used, or by his approved contractor, in accordance with the manufacturer's standard specifications.

Standard Insulation Specifications

Johns-Manville is prepared to furnish detailed standard specifications on any of the above items, as well as on the following and many others:

Boilers,
Boiler Settings,
Tube Doors,
Breechings and Smoke Flues,
Stack Lining, Stack Insulation,
Feed Water Heaters,
Pump Cylinders,
Hot Water Piping,
Ice Water Piping,
Refrigeration Piping,
Pipes Exposed to Freezing.

Space limitations do not permit the insertion of complete efficiency tables, pipe sizes, insulation thickness, etc. If you do not find the size you want, write to the nearest Johns-Manville Division sales office.

JOHNS-MANVILLE 85% MAGNESIA INSULATION

An efficient insulation for steam lines to 600 deg. fahr.

EFFICIENCIES

Pipe Size Inches	Nominal Insulation Thickness Inches		Temperature Difference Between Pipe and Surrounding Air, Deg. Fahr. 100°	200°	300°	400°	500°
			Temperature of Pipe, Deg. Fahr. (Temperature of Surrounding Air, 75 Deg.) 175°	275°	375°	475°	575°
			Heat losses per linear foot of bare pipe per hour and Efficiencies of insulation				
1	0	Bare Pipe Loss, B.t.u.	74.0	183.4	337.4	555.2	846.2
	Std.	Efficiency %	69.09	74.04	77.90	81.43	84.15
	2	" %	78.15	81.76	84.63	87.19	89.16
	3	" %	81.55	84.65	87.05	89.21	91.87
2	0	Bare Pipe Loss, B.t.u.	133.9	331.5	608.3	1003.9	1530.1
	Std.	Efficiency %	76.49	80.27	83.22	85.92	88.01
	2	" %	83.41	86.19	88.36	90.31	91.77
	3	" %	86.25	88.51	90.33	91.94	93.19
3	0	Bare Pipe Loss, B.t.u.	197.3	488.8	896.8	1480.0	2255.8
	Std.	Efficiency %	78.70	82.10	84.75	87.19	89.09
	2	" %	85.35	87.77	89.66	90.37	92.70
	3	" %	88.29	90.25	91.78	93.16	94.21
4	0	Bare Pipe Loss, B.t.u.	253.5	627.9	1152.1	1901.3	2897.09
	Std.	Efficiency %	80.90	83.99	86.36	88.55	90.26
	2	" %	86.50	88.71	90.46	92.03	93.28
	3	" %	89.30	91.15	92.52	93.75	94.71
6	0	Bare Pipe Loss, B.t.u.	371.9	923.7	1694.9	2797.1	4265.6
	Std.	Efficiency %	82.24	85.01	87.26	89.29	90.87
	2	" %	87.68	89.75	91.35	92.76	93.87
	3	" %	90.50	92.11	93.35	94.45	95.30
8	0	Bare Pipe Loss, B.t.u.	485.7	1203.0	2207.3	3642.8	5552.2
	Std.	Efficiency %	84.05	86.60	88.60	90.41	91.85
	2	" %	88.39	90.32	91.81	93.16	94.19
	3	" %	91.16	92.65	93.80	94.84	95.64
Flat Surface	0	(Bare Surface) B.t.u.	215.2	533.0	978.0	1614.0	2460.0
	1	Efficiency %	84.16	86.50	88.37	90.11	91.46
	2	" %	91.31	92.61	93.61	94.55	95.29
	3	" %	94.01	94.90	95.58	96.23	96.75

JOHNS-MANVILLE ASBESTO-SPONGE FELTED INSULATION

For insulating high pressure and superheated steam lines to 700 deg. fahr.

EFFICIENCIES

Pipe Size Inches	Nominal Insulation Thickness Inches		Temperature Difference Between Pipe and Surrounding Air, Deg. Fahr. 100°	200°	300°	400°	500°
			Temperature of Pipe, Deg. Fahr. (Temperature of Surrounding Air, 75 Deg.) 175°	275°	375°	475°	575°
			Heat losses per linear foot of bare pipe per hour and Efficiencies of insulation				
1	0	Bare Pipe Loss, B.t.u.	74.0	183.4	337.4	555.2	846.2
	1	Efficiency %	75.66	79.15	81.95	84.55	86.62
	2	" %	80.23	83.60	85.84	87.90	89.53
	3	" %	83.75	86.11	88.00	89.76	91.16
2	0	Bare Pipe Loss, B.t.u.	133.9	331.5	608.3	1003.9	1530.1
	1	Efficiency %	80.16	83.00	85.28	87.41	89.07
	2	" %	85.09	87.26	89.02	90.64	91.90
	3	" %	87.87	89.64	91.04	92.34	93.36
3	0	Bare Pipe Loss, B.t.u.	197.3	488.8	896.8	1480.0	2255.8
	1	Efficiency %	82.20	84.76	86.80	88.75	90.26
	2	" %	87.00	88.90	90.40	91.80	92.90
	3	" %	89.64	91.14	92.36	93.48	94.35
4	0	Bare Pipe Loss, B.t.u.	253.5	627.9	1152.1	1901.3	2897.09
	1	Efficiency %	83.24	85.60	87.55	89.35	90.75
	2	" %	87.96	89.71	91.10	92.42	93.44
	3	" %	90.56	91.94	93.04	94.06	94.84
6	0	Bare Pipe Loss, B.t.u.	371.9	923.7	1694.9	2797.1	4265.6
	1	Efficiency %	84.35	86.55	88.37	90.06	91.38
	2	" %	89.08	90.66	91.93	93.14	94.07
	3	" %	91.60	92.84	93.84	94.72	95.41
8	0	Bare Pipe Loss, B.t.u.	485.7	1203.0	2207.3	3642.8	5552.2
	1	Efficiency %	84.95	87.10	88.84	90.44	91.69
	2	" %	89.64	91.14	92.36	93.48	94.35
	3	" %	92.16	93.32	94.24	95.07	95.71
Flat Surface	0	(Bare Surface) B.t.u.	215.2	533.0	978.0	1614.0	2460.0
	1	Efficiency %	84.16	86.50	88.37	90.11	91.46
	2	" %	91.31	92.61	93.61	94.55	95.29
	3	" %	94.01	94.90	95.58	96.23	96.75

JOHNS-MANVILLE IMPROVED ASBESTOCEL INSULATION

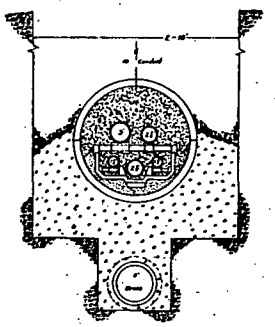
For insulating pipes conveying hot water or steam at medium and low pressure.

EFFICIENCIES

Pipe Sizes Inches	Ply		Temperature Difference Between Pipe and Surrounding Air, Deg. Fahr. 100°	150°	200°	250°	300°
			Temperature of Pipe, Deg. Fahr. (Temperature of Surrounding Air, 75 Deg.) 175°	225°	275°	325°	375°
			Heat losses per linear foot of bare pipe per hour and efficiencies of insulation				
1		Bare Pipe Loss, B.t.u.	74.0	123.8	183.4	253.7	337.4
	2-ply	Efficiency %	57.81	59.80	61.58	63.23	64.77
	3-ply	" %	62.86	64.83	66.60	68.22	69.69
	4-ply	" %	66.35	68.12	69.72	71.20	72.58
2		Bare Pipe Loss, B.t.u.	133.9	223.9	331.5	458.7	608.3
	2-ply	Efficiency %	64.49	66.12	67.58	68.89	70.10
	3-ply	" %	69.71	71.25	72.64	73.93	75.12
	4-ply	" %	73.04	74.45	75.72	76.89	78.00
3		Bare Pipe Loss, B.t.u.	197.3	330.1	488.8	676.3	896.8
	2-ply	Efficiency %	67.19	68.67	69.99	71.20	72.33
	3-ply	" %	72.62	74.03	75.28	76.38	77.39
	4-ply	" %	75.92	77.17	78.31	79.37	80.33
4		Bare Pipe Loss, B.t.u.	253.5	424.2	627.9	868.8	1152.1
	2-ply	Efficiency %	68.62	70.03	71.29	72.42	73.43
	3-ply	" %	73.96	75.29	76.47	77.57	78.58
	4-ply	" %	77.41	78.54	79.58	80.55	81.47
6		Bare Pipe Loss, B.t.u.	371.9	623.9	923.7	1278.1	1694.9
	2-ply	Efficiency %	70.02	71.38	72.57	73.68	74.66
	3-ply	" %	75.59	76.83	77.93	78.96	79.87
	4-ply	" %	79.03	80.12	81.08	81.97	82.82
8		Bare Pipe Loss, B.t.u.	485.7	812.5	1203.0	1664.5	2207.3
	2-ply	Efficiency %	70.96	72.20	73.32	74.35	75.31
	3-ply	" %	76.39	77.58	78.64	79.63	80.52
	4-ply	" %	79.83	80.87	81.80	82.65	83.47

JOHNS-MANVILLE UNDERGROUND SYSTEM OF INSULATION

A specially salt glazed and highly vitrified tile conduit is used as a waterproof envelope to protect the insulation—Johns-Manville Asbesto-Sponge Conduit Filling, is packed around the piping to be insulated and completely fills the conduit.



Section of Trench

The cast iron roll frame used is installed in a mortar or concrete bed and is set at the proper elevation from an overhead batter-board line. This method prevents uneven alignment of the pipes by irregularity in the manufacture of the conduit, etc.

The insulation used to surround the pipe is made of asbestos fibre and material of a sponge-like nature, which when properly mixed with the asbestos, forms the most efficient and durable insulation for underground work.

The underdrain laid with open joints carries away the water that rapidly filters away from the system through the broken stone or gravel in which the lower half of the system and the underdrain itself is laid.

Shutters for sealing the ends of the system, manhole and anchor pits, are incidental but necessary, and are placed according to conditions and requirements as recommended by our engineers.

Insulating Products Corporation

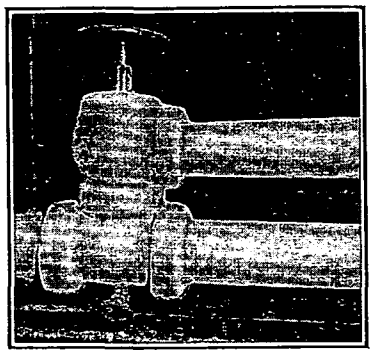
280 Madison Avenue at 40th Street,
New York

Insulating Products Company

Factory and General Offices: AURORA, ILLINOIS

Webers 48 Insulating Cement

A heat insulation of exceptional non-conducting value, entirely different from other insulating materials and suitable for flat, curved or irregular sufaces.



Webers 48 applied to pipes, valves, etc.

Webers 48 Insulating Cement

Mixes readily in fresh water, is easily applied to hot or cold surfaces, adheres strongly to brick, metal and other surfaces without reinforcement. It provides a monolithic wall of insulation without cracks, seams or joints and is fully reclaimable without loss of insulating value. The latter item is of great importance where changes or repairs are necessary.

Webers 48 Insulating Cement

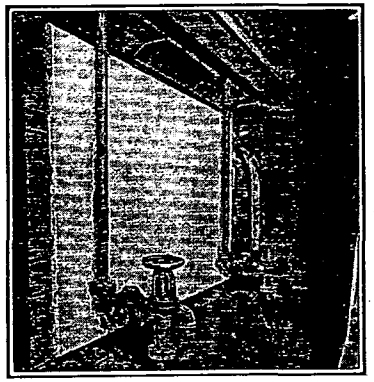
Through its labor saving qualities, durability and low maintenance cost, considerable economy is effected. It retains its original characteristics under high temperatures, is dielectric and unaffected by acid fumes.

Webers 48 Insulating Cement

Has a covering capacity of approximately 1000 sq. ft., one inch thickness, per ton. It is therefore extremely economical in application.

Webers 48 Insulating Cement

—withstands vibration.
—responds readily to normal expansion and contraction.
—can be waterproofed by sizing and painting.
—simplifies storage question by eliminating odd sizes and shapes.
—does away with breakage losses.



Webers 48 applied to flat surfaces

Webers 48 Insulating Cement

is being successfully used to insulate the following types of equipment:

Accumulators	Evaporators	Furnaces
Boilers	Economizers	Heaters
Breechings	Fittings	Tanks
Ducts	Flanges	Valves

Boiler furnace water walls and all flat, curved or irregular surfaces.

Shipped in Bags of 50 lbs. Net

Our engineering service is at all times available for consultation. We also contract for complete installations of any size.

Telephone
Main 9200

Established 1910

The Ric-wiL Company

UNDERGROUND CONDUIT SYSTEMS FOR HEATING PIPES

Union Trust Building **CLEVELAND, OHIO**

AGENTS IN PRINCIPAL CITIES—REFER TO LOCAL TELEPHONE DIRECTORY

Products—RIC-WIL Conduit, which includes Base Drain, Pipe Supports, insulation and other accessories for underground steam, hot water and fuel oil pipes. Cast Iron conduit for extra heavy duty Manhole Covers Insulating.

Ric-wiL Conduit—Hard burned and glazed tile, bell and spigot type, which splits on the job for easy installing. Special Loc-Lip Side joints seal top and bottom halves together again after pipes and insulation are installed, a strong water-tight joint. Sections 2 ft. long, sizes I. D. 4 to 24 in.

Ric-wiL Base Drain—Hard burned and glazed tile designed to be a base for supporting and lining up conduit and drain for carrying away moisture. Slotted sections interlock with conduit bells to form a strong construction. No concrete foundation necessary in solid ground. Three sizes: No. 1 for 4 and 6 in. conduits, No. 2 for 8 to 15 in., No. 3 for larger sizes.

Ric-wiL Pipe Supports—Planned to carry one to five or more pipes and ordinarily spaced 12 ft. apart. Made of cast-iron, rust proofed, and interlocked with the base drain, imposing no load on the conduit itself. Pedestal type supports on special order.

Ric-wiL Conduit Systems for All Uses—*Type SPC* system for steam heating and power pipes and superheated steam. Insulation provided by standard pipe covering applied directly to pipes.

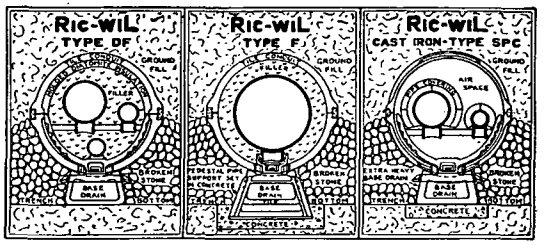
Type F system for steam heating and power pipes. Unlined RIC-WIL conduit with filler packed around pipes. DRY-PAC Waterproof Filler if desired.

Type DA system for hot water, fuel oil and condensation returns. Sil-o-cel insulation moulded to inside of tile and keyed in. Pipes insulated from outside earth but not from each other.

Type DF system for steam heating and power pipes. Type DA with addition of RIC-WIL Conduit filler packed around pipes. DRY-PAC Waterproof Filler if desired.

Cast Iron Ric-wiL Conduit—For extra heavy duty under railroads or other places where conduit is subject to abnormal strain. Similar in design to tile Ric-wiL. Special reinforced base drain.

Engineering Service—Maintained for the convenience of customers. Inquiries answered promptly. Catalogs and special information on request.



ADVANTAGES OF THE RIC-WIL SYSTEM

MECHANICAL

WATER-TIGHT: JOINTS COMPLETELY SEALED AND CEMENT LOCKED IN.

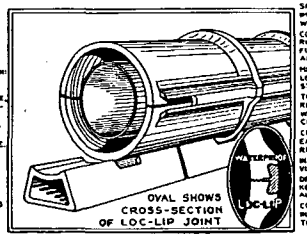
STRENGTH: AMPLE FOR USUAL CONDITIONS. 40% STRONGER THAN ANY OTHER TILE SYSTEM.

INTERLOCKING CONSTRUCTION: CONDUIT AND BASE DRAIN STAGGER JOINTS, PIPE SUPPORTS LOCKED IN PLACE TOP AND BOTTOM OF CONDUIT LOCKED TOGETHER AND CEMENT LOCKED IN.

FOOL PROOF: TOP AND BOTTOM OF CONDUIT ALIKE. CAN NOT INSTALL UP SIDE DOWN.

BASE DRAIN: FOUNDATION AND CRADLE FOR CONDUIT TO REST ON.

PERMANENCY: MATERIALS ALL OF PERMANENT CHARACTER.



PRACTICAL

SPEED OF INSTALLATION: IMPORTANT FOR STREET WORK.

COMPLETE SYSTEM: RIC-WIL SYSTEMS ARE FURNISHED COMPLETE IN ALL DETAILS.

MINIMUM PUBLIC LIABILITY: LESS CONSTRUCTION IN STREETS.

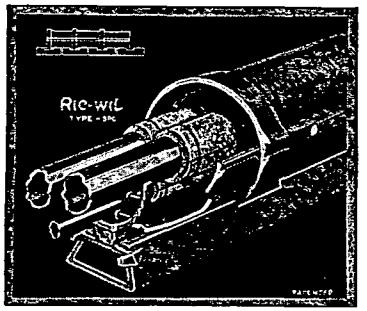
TRENCH WIDTH: RIC-WIL REQUIRES LEAST TRENCH WIDTH SAVES ON PAVING COST.

CEMENTING JOINTS: EXTRA EASY. CEMENT A WHOLE RUN AT ONE TIME.

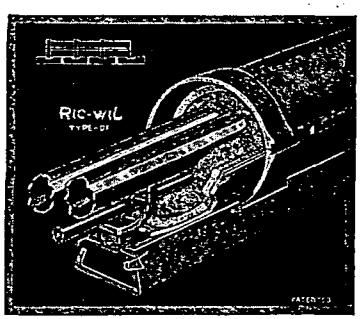
INSPECTION: LOC-LIP JOINT VISIBLE FROM TOP OF TRENCH.

DRY INSULATION: DESIGN KEEPS INSULATION DRY AT ALL TIMES - EFFICIENCY.

COST: LABOR COST OF INSTALLATION IS LOW, AND TOTAL COST IN LINE.



Ric-wiL Type SPC illustrated. Type F is also an unlined conduit, insulation being a loose filler packed around the pipes



Ric-wiL Type DF with loose filler packed around pipes. Type DA also has insulation moulded to tile, but without loose filler

Armstrong Cork & Insulation Company

Pittsburgh, Pa.

Offices

Albany	Chicago	Houston, Tex.	New York
Atlanta	Cincinnati	Jacksonville, Fla.	Rochester
Birmingham	Cleveland	Kansas City	St. Louis
Boston	Dallas	Memphis	Montreal, Que., Can.
Buffalo	Denver	Milwaukee	Toronto 2, Ont., Can.
Charlotte, N.C.	Detroit	Minneapolis	

Armstrong Cork Company, Ltd., London, England

Representatives

Baltimore	John R. Livezey	San Francisco	Van Fleet-Freear Co.
Los Angeles	Gay Engineering Corp.	Seattle	D. E. Fryer & Co.
New Orleans	H. T. Steffee	Spokane	D. E. Fryer & Co.
Philadelphia	John R. Livezey	Tacoma	D. E. Fryer & Co.
Portland	Gillen-Cole Co.	Washington	John R. Livezey

Detailed information, samples, and descriptive literature may be obtained on application to any of these offices or representatives.

Something over 50 per cent of the heat supplied to an uninsulated residential building is lost by conduction and radiation through the walls and roofs. But when the house is insulated with the recommended thicknesses of Armstrong's Corkboard this loss is so materially reduced that it can be heated comfortably with a smaller plant and on less fuel.

Reference is made to Chapter I, Calculating the Heat Losses from Buildings, and particularly to the tables on pages 22 to 47 which very clearly show the remarkable heat saving effect of adding 1½ or 2 in. of corkboard to standard wall and roof constructions. The reduction in heat loss amounts to from 50 to 75 per cent. This means that an adequate thickness of corkboard on walls and roof reduces the heat wastage, and therefore the heat requirements, of the house by 25 to 40 per cent.

Advantages of Insulation

These savings, calculated and theoretical, are fully confirmed by the actual experience of hundreds of home owners. Cork-insulated houses all over the country are being heated with smaller furnaces and boilers and radiation a third or more less than would otherwise be installed, also with a corresponding economy of fuel consumption.

Furthermore, cork-insulated houses are heated much more uniformly, have no *cold side* or rooms that are *hard to heat*, and are decidedly freer from drafts. The greater comfort and economy of the cork-lined house reacts directly to the benefit of the heating engineer or contractor, since it reflects credit on the efficiency of his plant and the value of his services. Furthermore, by taking advantage of the heat saving effected by the insulation, the contractor builds up an invaluable fund of good will for himself by pointing out the economies he is able to offer with the reduced size and cost of heater and radiation.

Roof Insulation

Similar economies are effected in industrial heating where, as a rule, the roof of the building only is insulated. One of the greatest heat losses is through the roof and its adequate insulation with Armstrong's Corkboard gives very positive results decidedly to the advantage of both owner and contractor.

Thickness of Insulation

One point to be guarded against in basing calculations on the heat-saving value of insulation is the *thickness* in which the insulation is used. For residences, the insulation of exterior walls should be 1½ in. of Armstrong's Corkboard and for

roofs or top-floor ceilings, 2 in. These thicknesses have been established as affording the maximum of comfort and economy per dollar of insulation investment. The transmission figures given in the tables on pages 22 to 47 are for these thicknesses and the values shown can be depended upon for estimating heating requirements.

For roofs of commercial and industrial buildings, the thickness varies with conditions. Not less than 1 in. should be used in any case, preferably 1½ or 2 in. Where there is high humidity inside the building and ceiling sweat, the conditions should be analyzed by a competent engineer to determine the thickness necessary to prevent condensation.

Armstrong's Corkboard

Armstrong's Corkboard has been the standard insulation in the industries for the past 25 years. Many millions of feet of it are in use in cold storage plants, refrigerators, refrigerator cars, and in other industrial rooms where temperature control is essential. Its dependability and permanence have been proved under all kinds of conditions.

Armstrong's Corkboard is composed of clean granules of pure cork, compressed and solidified by a baking process into firm, semi-rigid sheets of uniform quality. Armstrong's Corkboard is made in boards measuring 12 x 32 in. and 36 in., 1, 1½, 2, 3, 4, and 6 in. thick. It is obvious that with this range of sizes, any thickness required for house insulation or commercial roof insulation can be applied in a *single thickness* and therefore at a considerable saving in labor cost.

Armstrong's Corkboard is light in weight, about 0.8 lb. per square foot 1 in. thick. It can be easily erected in any type of construction, being applied in Portland cement mortar against masonry walls, nailed to studs, joists, and rafters, and laid in asphalt or pitch on roof decks. Regular house plaster is applied directly on the corkboard without lath, and standard roofings laid over the cork in the same manner as on the roof deck.

Further Information

Complete specifications and detailed information will be found in the book, "The Insulation of Walls and Roofs with Armstrong's Corkboard," which will be mailed on request.



Illustrating Armstrong's Corkboard being applied on the underside of roof rafters in a residence.

Banner Rock Products Company

MANUFACTURERS OF ROCK WOOL INSULATION

Alexandria, Indiana

PRODUCTS: High temperature insulation for all temperatures up to 1200° F.: Banroc Wool, Banroc Jacket, Banroc Pipe Insulation, Under-ground pipe insulation, High temperature water-proofing cements, Insulating Cements for temperatures to 1800°F.

Cold storage insulation for use in all types of refrigerated construction: Rock Cork, Granulated Rock Cork.

BANROC PRODUCTS

SERVICE:

Branch offices and distributors in principal cities can furnish and apply Banroc Insulation.

The Banner Rock Products Company maintains an efficient corps of engineers and is prepared to make a study of your heat insulation problems and give individual engineering service on them.

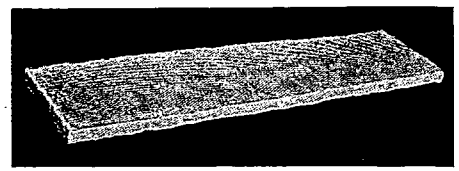
Domestic Insulation—Banroc Hominsul for insulating homes
Banroc Furnace Jacket for Hot Air Furnaces

Banroc Wool—Banroc Wool, the basic material from which all Banroc Products are made, is a highly efficient thermal insulation, consisting of fine glass-like fibres of rock material, which entrap tiny air cells, that comprise about 92 per cent of its volume.

It is made from a peculiar rock, found in our own quarries. The rock is first melted in the intense heat of special furnaces, and then blown into tiny fibres by means of high pressure jets.

Tests made by the United States Bureau of Standards show that Banroc Wool has a thermal conductivity of 0.275 B.t.u. per hour, per square foot for 1 in. thickness and a temperature differential of 1 deg. fahr. at a mean temperature of 77 deg. fahr. Comparing this conductivity with competing materials proves that Banroc Wool has a low conductivity, and is, therefore, a very efficient high temperature insulating material. This fact is further demonstrated by tests by some of the largest insulation users in the country.

The entire mineral composition of Banroc Wool makes it free from decay or deterioration. It is not subject to chemical reactions which cause disintegration. Banroc Wool is fireproof. It will function with high efficiency at any temperature from 275 deg. fahr. below zero to 1200 deg. fahr. above zero.



Banroc Jacket

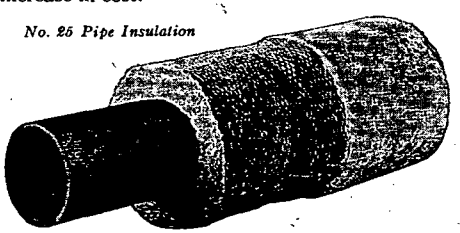
Banroc Jacket—Banroc Jacket is a flexible insulating material, made of selected Banroc Wool, felted between copper bearing metal fabrics of various types to meet special conditions. It is adaptable for the insulation of all hot surfaces, ranging in temperatures between 100 deg. fahr. and 1200 deg. fahr.

Banroc Jacket is fireproof, will not decay or deteriorate, can be removed and replaced without injury, is unaffected by chemical or climatic conditions, is highly efficient and economical.

Banroc Jacket is made in standard sections 2 ft. by 8 ft. and 2 ft. by 4 ft., in 1, 1½, 2, 2½, 3, 3½, 4, 5 and 6 in. thickness. Special sizes to meet special conditions can be furnished on short notice at a small increase in cost.

Banroc Pipe Insulation—Banroc Pipe Insulation is manufactured from Banroc Wool to meet the need of industry for a highly efficient, durable, and economical insulation for pipes carrying high temperatures. It is not a "covering" but an insulation that effectively and economically keeps the heat in the pipes.

No. 25 Pipe Insulation

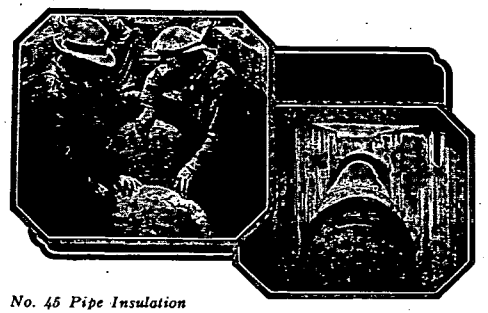


Expansion and contraction of pipes does not damage it. Joints can not open up with resulting loss of efficiency. This fact insures the continuance of the high initial efficiency.

Banroc Pipe Insulation is made in four standard styles to meet various conditions of service. Style No. 25 is made by felting and securing Banroc Wool between metal fabrics. This inside fabric is a high grade fine mesh wire netting cut and spaced to exactly meet the outside circumference of the pipe. The outside metal fabric is copper bearing, metal lath, of a length equal to the outside circumference of the pipe insulation. This insures a continuous insulation around and along the pipe.

Style No. 25, furnished in 2 ft. sections in thicknesses of 1 to 4 in., for use on pipes 2 in. diameter or larger. For use on hot lines where a plaster finish is to be used.

Style No. 45 is of the same construction as No. 25, except a heavy, reinforced waterproof paper is used on the outside instead of the metal lath. Asbestos roofing of the highest grade, cut in sections to fit, is furnished with style No. 45 as a waterproof and durable covering. For use where a waterproof and weather-proof finish is desired. Used extensively for underground steam lines.



No. 45 Pipe Insulation
Applied to Underground Steam Lines

Style No. 65 is of the same construction as No. 25, with a 24 gauge ingot iron outer casing, attached by a patented flange and rivet construction to the copper bearing metal lath. It is especially recommended for use around refineries and other process plants where a removable and replaceable insulation that is waterproof, fireproof, durable and efficient, is desired.

Furnished in thickness 1½ to 4 in., in 2 ft. sections with 2 in. extra for end lap. For use on pipes of 3 in. diameter or larger.

Style No. 85 is the same as style 45, with an 8 oz. Canvas Cover instead of the asbestos roofing cover.

Banroc Insulating Cements—Banroc Wool has been compounded into a line of insulating cements that are admirably suited for the various purposes intended. They have good coverage, excellent finish and high insulating efficiencies.

No. 16 Cement—Banroc No. 16 Cement is especially suited for finishing Banroc Jacket and Banroc No. 25 Pipe Insulation. It is light in weight, easy to mix and apply, finishes with a hard white surface that does not crack or peel and has a good insulating efficiency.

No. 18 Cement—Banroc No. 18 Cement is a high grade cement with a high insulating value. It is recommended for use on fittings and irregular surfaces where it is impracticable to apply Banroc Jacket or Pipe Insulation. It will adhere readily to hot or cold surfaces with a minimum of shrinkage. Because of its high insulating value it is more or less porous and can not be used for a finishing cement. It can be reclaimed and used again by remixing with water.

Anti-Therm Cement—Banroc Anti-Therm Cement was developed as a part of the Banroc Fireproofing Specification for fireproofing structural steel. It has a marvelous heat absorbing quality that prolongs the life of steel members in a fire. The Banroc Fireproofing Specification has given marvelous protection in fire tests.

Banroc Cements are shipped in 100 lb. bags.

Rock Cork—Rock Cork is a cold temperature insulation made of Banroc Wool, mixed with waterproof binders, formed and baked into blocks. For complete information send for Rock Cork Bulletin.

Banroc Hominsul—Banroc Hominsul is a highly efficient, economical insulating material in granular form, made especially for use in the home. It is a dry insulation and is placed between studs in side walls or between rafters in ceiling. Send for complete information.

The Celotex Company

General Office

Branches in Principal Cities — 645 N. Michigan Avenue, Chicago, Ill. — **Mill** — New Orleans, La.

CELOTEX
INSULATING CANE BOARD

Outstanding Characteristics of CELOTEX

High Insulating Value
Tough and Durable
Structural Strength
Light in Weight
Easily Worked with Tools
Cheaply Installed
Sound-Deadening Properties
Undergoes No Physical or Chemical Change after Installation.
Reasonable in Price
Protects against Dampness

CELOTEX Quickly Available

CELOTEX Standard Building Board and CELOTEX Lath are stocked by lumber dealers in every locality throughout the United States and Canada. This availability is a money-saving convenience in conducting construction work according to schedule.

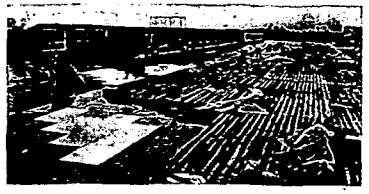
Other CELOTEX Products are supported by a highly organized shipping service which reduces to a minimum time consumed for transit.

Competent Engineering Service

The careful consideration of insulating requirements, and their influence on specifications covering heating and ventilating equipment, invariably gives rise to situations demanding special study. As a means of simplifying the work in such cases, The CELOTEX Company maintains an experienced engineering staff. The cooperation of this staff is available to Architects and Heating and Ventilating Engineers without cost.

CELOTEX Cane Fibre Insulation

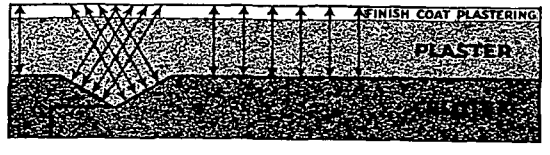
A practical insulating material must be tough, strong and light in weight. Cane fibre supplies these properties to a superior degree. CELOTEX is the only insulating material made from cane fibres.



CELOTEX ROOF INSULATION

For Industrial, Commercial and Apartment Buildings

The importance of effective roof insulation as well as its relationship to heating and ventilating requirements has become generally recognized as a practical source of economy to which the building owner is entitled. To provide the utmost in economy of installation CELOTEX Roof Insulation Board is manufactured in thicknesses of ½, 1, 1½, 2, 2½, 3, and 4 in. The individual boards measure 2 ft. wide by 5 ft. long. Complete data relative to proper roof protection is available without cost or obligation. It includes complete facts on the solution of roof-condensation problems.



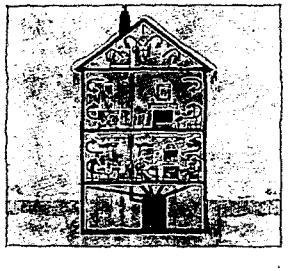
CELOTEX LATH

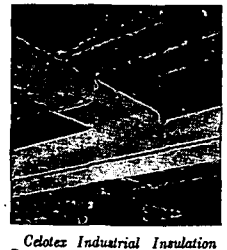
Because of its insulating value, CELOTEX Lath materially reduces the transmission of heat through walls and ceilings. In addition, the special "ship-lap" joint (patent applied for) eliminates open spaces between the lath. Heat transmission coefficients of various types of walls and ceilings plastered over CELOTEX Lath will be sent upon request. Ask for complete "Heat Insulation Data."

CELOTEX
INSULATING CANE BOARD

Standard Building Board

In the small house, large residence or in apartment buildings the use of CELOTEX Standard Building Board as structural insulation has a direct influence upon the size of heating equipment. The more general the use of gas or oil, the more important becomes the question of insulation. In fact, the economical use of these fuels depends entirely upon an insulated structure.





Celotex Industrial Insulation Board used for temperature insulation of the cold air ducts in Jewish Hospital, St. Louis, Mo., Graham, Anderson, Probst and White, Chicago, Ill., Architects.

Air Duct Insulation—CELOTEX Industrial Insulation Board is manufactured specially for uses such as this. It is supplied 3 ft. wide, and in a variety of lengths and thicknesses.

Tank Insulation—Data concerning tank insulation for storage tanks of various capacities and for liquids of different kinds is available on request.

ACOUSTI—CELOTEX

FOR LESS NOISE — BETTER HEARING

Acousti CELOTEX, because of its high sound absorption properties, is very effective in quieting noisy ventilating ducts. By lining the duct for some distance with Acousti CELOTEX, noises created by the fan and the air rushing through the duct are absorbed.

Samuel Cabot
Incorporated

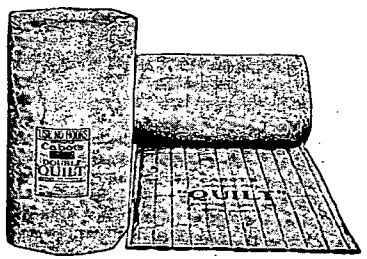
141 Milk Street — **Boston, Mass.**

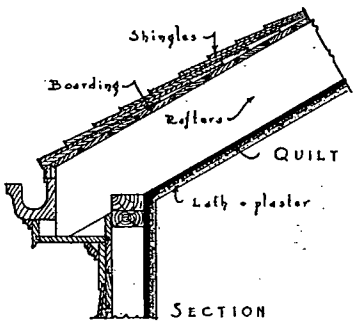
101 Park Avenue, NEW YORK
5000 Bloomingdale Avenue, CHICAGO

PHILADELPHIA, KANSAS CITY, LOS ANGELES,
SAN FRANCISCO, SEATTLE, PORTLAND, ORE.

Cabot's Heat-Insulating Quilt (Trade Mark)

Cabot's Quilt is the original flexible insulator. It is made in three thicknesses—single, double and triple—is 36 in. wide and shipped in rolls covering 250 sq. ft. each. **Quilt** is made of Zostera Marina, gathered on the Bay of Fundy, and will not rot, will not burn and will not harbor insects or vermin.





Quilt *Insulation in Roof and Wall Construction*

U. S. Government Bureau of Standards Letter Circular No. 227, reporting tests of numerous Insulating Materials, gives **Cabot's Quilt** a Thermal Conductivity rating of 0.25 which was equalled by only two other insulators, regardless of cost.

Tests conducted by Prof. Gordon B. Wilkes, of the Massachusetts Institute of Technology, show the following savings in heat leakage in different methods of construction, by the use of **Cabot's Quilt.**

WALL CONSTRUCTION	Conductivity Uninsulated "H"	Conductivity Insulated with Cabot's Double Ply Quilt—"H¹"	Percentage Heat Saving
Clapboard, studding	0.70	0.26	63
Clapboard, studding, lath, plaster	0.44	0.21	52
Clapboard, sheathing, studding, lath, plaster	0.28	0.16	43
8 in. brick	0.40	0.20	50
8 in. brick, furring, lath, plaster	0.27	0.16	41
4 in. tile, stucco, outside, plaster inside	0.40	0.20	50
12 in. concrete	0.46	0.21	54
Corrugated iron	1.50	0.32	79
12 in. stone	0.49	0.22	55
12 in. concrete, furring, lath, plaster	0.40	0.20	50
Stucco, studding, plaster	0.45	0.21	53

ROOF CONSTRUCTION	Conductivity Uninsulated "H"	Conductivity Insulated with Cabot's Double Ply Quilt—"H¹"	Percentage Saving
Tar, gravel on 4 in. concrete	0.60	0.24	60
Metal on tongue and groove sheathing	0.42	0.20	52
Corrugated iron on wood frame	1.80	0.32	82
Tile or slate on wood sheathing	0.82	0.27	67
Tar, gravel, tar paper, 2 in. wood plank	0.26	0.16	39
Shingles, sheathing, studding, lath, plaster	0.30	0.17	43
Wood shingles on shingle lath	0.64*	0.24	63

*Average value from JONES' tables, *The Heating and Ventilating Magazine.*

The cost of **Cabot's Quilt** is so low, for material and application, that reduction in Heating Equipment warranted by above figures more than pays for entire insulation. The annual fuel saving is pure velvet.

Fire-resistant: Quilt is a *real* fire-resistant. It will not smoulder or carry fire.

Will not Rot: Quilt will not rot. It will last as long as the building.

Flexible: Quilt will fit any surface, or around corners or jogs. Lowest labor cost.

The Insulite Company

Builders' Exchange Building

Minneapolis, Minn.

INSULITE
the Wood-Fiber Insulating Board

Insulite is a wood-fiber insulating board made from the long, coarse, fibers of the spruce and other northern woods. The strong fibers are felted together in such a way as to form rigid boards containing innumerable air cells. Due to the fact that these small air cells, closely confined, and in large quantities, form a heat resisting material, Insulite affords a high degree of insulating efficiency as shown by many unbiased laboratory tests conducted by various authorities in this field.

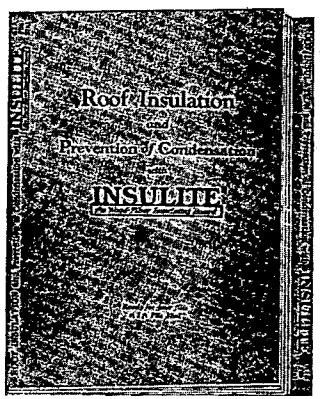
It is made in a thickness of half inch, but when used for roof insulation two half-inch thicknesses are stapled together with non-corroding metal staples, affording a full inch of serviceable and substantial insulation, an important feature of which is the lapped edges which provide a heat-sealing factor not obtainable when ordinary square-edge material is used.

In our book, "Roof Insulation and the Prevention of Condensation" which is illustrated here, and which will be sent without obligation to any one interested, the various important phases of prevention of condensation and roof insulation are thoroughly covered.

Through various analytical examples it is easily possible for the heating and ventilating engineer to determine not only the amount of insulation to use to get most efficient results, but tables show how to figure fuel savings, radiation savings, dollars and cents savings in investment, and other information of equal interest.

The Prevention of Condensation is a subject which has had a growing amount of attention among heating and ventilating engineers because of the great losses through this source. Not only is there loss in heat and fuel, but because of dripping water which has condensed on roofs and ceilings thousands of dollars worth of valuable equipment, machinery, and finished products are ruined annually. This subject is given important consideration in the book referred to, not only as to its prevention, but actual tables are shown which make it possible for even the inexperienced to determine the amount of insulation that is necessary to overcome condensation under various conditions.

For the assistance of engineers, the INSULITE COMPANY maintains a Service Department composed of technical men with latest information data at their finger tips. These men will gladly work with you on any problem pertaining to insulation. They will answer any questions that may come to your mind on the subject, as well as render you any service within their powers. There is no obligation whatsoever—the opportunity of being of service will be welcomed.



Flax-li-num Insulating Company

Chicago Office
228 North La Salle

Home Office and Factory
St. Paul, Minnesota

New York Office
ARCHITECTS BUILDING,
101 Park Avenue

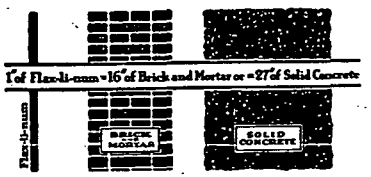
Manufacturers of FLAX-LI-NUM

Flax-li-num is a thermal insulation and sound control material used for many years in various industries to meet existing insulation requirements. FLAX-LI-NUM is a semi-rigid board felted from the long tough fibres of the flax plant and naturally FLAX-LI-NUM is durable and assures the user that the insulation will last as long as the building stands.



Flax-li-num is vermin and rodent proof and is guaranteed by the manufacturers never to fall down or become displaced in a building wall. As the material is of *semi-rigid* type it cannot warp, break or crack, and it should not be considered as a substitute for ordinary wood or metal lath, sheathing or other parts of a building construction.

The FLAX-LI-NUM insulation method has been developed for roofs and walls of frame, brick, hollow tile or veneer constructions, and to give the user the full benefit of its heat insulation and sound proofing qualities.



Flax-li-num was introduced in 1909, first, to insulate railroad refrigerator cars, and has extended its application in the past fifteen years to a variety of insulating services in residences and industrial buildings and in many specialty markets, such as iceless shipping containers and kindred products.

The use of FLAX-LI-NUM in buildings, brings definite economies in fuel and radiation required, as well as the production and maintenance of healthful conditions. Heat transmission coefficients are given for various types of walls and roofs.

To get the best service from FLAX-LI-NUM specify the exact place where insulation is to go. The effectiveness of insulation is increased if applied between studdings, midway between the sheathing and lath and plaster for frame construction, or furred out on masonry construction. FLAX-LI-NUM for walls should be at least ½ in. thick and for roofs 1 in. thick.

The FLAX-LI-NUM method of application of insulating material to all types of construction is fully covered in our booklet, "Heat Insulation for Houses"—A. I. A. File 37-b-1. There is also contained in this booklet the FLAX-LI-NUM radiation chart which greatly simplifies the accurate computation of radiation where heat loss factors are known. A copy of this publication should be in the files of every engineer and architect, and will be sent on request.

Heat Loss factors for various insulated and uninsulated walls of stucco, brick and frame construction are fully covered in the publication "Heat Insulation for Houses."

These walls are listed below with their *K* values, showing how these values are substantially reduced by the addition of FLAX-LI-NUM in accordance with our standard specification which calls for ½ in. FLAX-LI-NUM in side walls and 1 in. ceilings or roofs.

Stucco Walls

A-1. Standard frame construction furred out over sheathing, metal lath and stucco. Lath and plaster inside ..... .242

B-1. Same as above but with ½ in. Flax-li-num added ..... .146

C-1. Standard frame construction with Byrkett sheathing. Stucco directly on sheathing. Lath and plaster inside ..... .287

D-1. Same as above with ½ in. Flax-li-num added ..... .161

E-1. Frame construction. Metal lath directly on studs. Stuccoed outside and back-plastered. Lath and plaster inside ..... .357

F-1. Same as above with ½ in. Flax-li-num added ..... .181

Brick and Tile Walls

A-2. Standard frame construction. Lath and plaster inside. Face brick veneer ..... .210

B-2. Same as above with ½ in. Flax-li-num added ..... .133

C-2. 8 in. hollow tile. 4 in. Face Brick, plastered directly on tile .255

D-2. Same as above, but furred inside with 1 by 2 in., plastered on Flax-li-num Keyboard ..... .141

E-2. Standard 13 in. solid brick wall, furred inside, lath and plaster .191

F-2. Same as above with Flax-li-num Keyboard as plaster base ..... .146

Frame Walls

A-3. Standard frame construction. Sheathing, paper and siding outside. Lath and plaster inside ..... .255

B-3. Same as above with ½ in. Flax-li-num added ..... .151

C-3. Standard frame construction, same as A-3, except plastered on lumber substitute ..... .216

D-3. Same as above with ½ in. Flax-li-num added ..... .136

E-3. Standard frame construction, same as A-3, except lumber substitute used for sheathing ..... .229

F-3. Same as above with ½ in. Flax-li-num added ..... .141

Roofs and Ceilings

A. Standard frame construction. Wood shingles, attic floor. Lath and plaster ..... .179

B. Same as above, with 1 in. Flax-li-num under ceiling joist furred down for lath and plaster .104

C. Standard frame construction, same as A, without attic floor. .284

D. Same as B, without attic floor. .132

E. Standard frame construction, attic floor, tile roof ..... .163

F. Same as E, with 1 in. Flax-li-num under ceiling joist furred down for lath and plaster ..... .098

One of the fields in which FLAX-LI-NUM finds extensive use is in the insulation of industrial roofs, where it serves to reduce heat losses, secures greater comfort for workers and corrects condensation difficulties which hamper production in many instances. It is also extensively used for sound control and acoustical correction.

All details pertaining to the above uses are covered in the aforementioned publication; "Heat Insulation for Houses."

MACANDREWS & FORBES COMPANY
200 FIFTH AVENUE, NEW YORK

MAFTEX

The "Thermal-Insulating" Board that has Structural Strength

PRODUCTS:

MAFTEX STRUCTURAL INSULATING BOARD for sheathing, sound-proofing, etc.

MAFTEX ROOF INSULATING BOARD for flat roof decks, sound-proofing, etc.

MAF-LATH—the ideal plaster base.

MAFTEX REFRIGERATOR BOARD.

GENERAL CHARACTERISTICS:

MAFTEX products are made from the roots of the licorice plant by a special process developed by the MacAndrews & Forbes Company. The thoroughly extracted, washed and sterilized root fibres are processed to produce a non-laminated board of great structural strength and remarkable thermal resistance.

Licorice root fibres are inherently resistant to attack by vermin and bacteria to a remarkable degree. This natural characteristic together with the sterilization and chemical treatment incidental to processing MAFTEX insures permanence.

Experimental board produced 20 years ago still retains its strength and other physical characteristics.

MAFTEX may be sawed, nailed or sandpapered readily. The sheets are strong enough to permit handling without danger of destroying the edges.

The ripple surface of MAFTEX not only furnishes an ideal base for gypsum plaster but permits of unusual decorative effects when painted or stained.

Structural Strength:

Numerous comparative distortion tests between walls sheathed with MAFTEX and wood sheathing show that even under very severe stresses the distortion of MAFTEX structures is less than one-fifth as great as wooden ones.

Of equal importance is the fact that MAFTEX structures are sufficiently resilient to return to their original position after severe stress.

Insulating Value:

MAFTEX is *primarily* an insulating material. Tests conducted by Professor Gebhardt of the Armour Institute of Technology using the guarded hot-plate method showed that MAFTEX has a thermal conductivity of 0.337 B.t.u./sq. ft./inch/F°/hour. Its resistance to the flow of heat is therefore three times as great as that of wood and nearly twenty-five times as great as concrete.

Plaster Bond:

The ripple surface of MAF-LATH is an ideal base for gypsum plaster. When prepared and applied according to specifications gypsum plaster shows a bonding strength to MAF-LATH *greater than* 1000 lb. per square foot.

MAF-LATH in convenient 16 x 48 in. sheets may be economically and quickly applied by lathers. This product combines the insulating value and plaster bonding strength of MAFTEX with the convenience of wood lath.

Sound Deadening:

MAFTEX is widely applied as a medium for the absorption of sound. It is useful both as a sound insulator and for acoustical correction in auditoriums, broadcasting stations, etc.

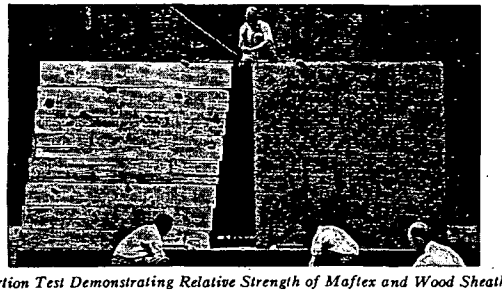
Sizes:

MAFTEX Structural Insulating Board is 1/6 in. in thickness, 4 ft. wide and 8, 9, 10 and 12 ft. long. Weight is approximately 750 lb. per 1000 sq. ft.

MAFTEX Roof Insulating Board is made in 4 ft. by 4 ft. sheets, approximately ½ in. in thickness.

MAF-LATH is cut in convenient size 16 x 48 in. for use by lathers as an insulating plaster base.

MAFTEX Refrigerator Board is cut to specified size for use by refrigerator and refrigerator car manufacturers.



Distortion Test Demonstrating Relative Strength of Maftex and Wood Sheathing

APPLICATIONS MAFTEX STRUCTURAL BOARD, AND MAF-LATH:

Roof Sheathing:

Under the usual roofing materials MAFTEX replaces wood sheathing on sloping roofs while giving insulation as well.

Side Wall Sheathing:

On side walls MAFTEX is used in place of the ordinary sheathing and gives added strength plus insulation.

Plaster Base:

MAF-LATH replaces wood lath or plaster board on walls and ceilings to receive plaster while also reducing heat transmission and absorbing sound.

Wall Finish:

Paints and stains produce beautiful effects on MAFTEX paneling applied to studs. If desired, the ripple surface itself forms an attractive finish.

Sound Deadening:

Under floors and on basement ceilings MAFTEX is used for its sound-absorbing qualities as well as for its insulation value.

APPLICATIONS MAFTEX ROOF INSULATING BOARD:

On account of its thickness MAFTEX ROOF INSULATING BOARD has an insulating value somewhat higher than Standard Structural MAFTEX and is intended for insulating purposes only. It is used on flat roofs to keep out the heat of the summer sun, for saving of fuel in winter, and to prevent condensation.

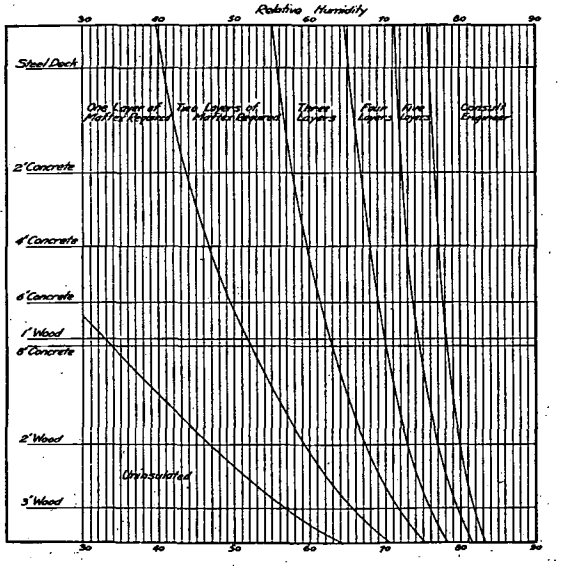
Correction of Condensation:

Excessive humidity incident to many industrial processes gives rise to condensation under flat roofs and on side walls. Such condensation is frequently detrimental to manufactured products and always to the structure on which it occurs.

In practically all cases the proper application of MAFTEX will correct condensation.

The chart below has been prepared to assist the engineer in determining the number of layers under ordinary conditions. The data used as the basis of this chart are a constant inside temperature at the roof line of 100 deg. fahr. and an outside temperature of 0 deg. fahr.

Where the range of temperatures varies from the above the Manufacturers will be glad to furnish a chart that indicates the number of layers of MAFTEX necessary for all conditions of temperature and humidity.



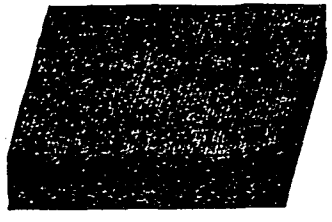
The Pantasote Company, Inc.

250 Park Ave., **New York City**

THERMASOTE

Weatherproof and Insulating Building Material

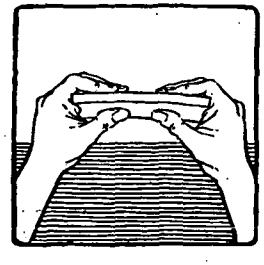
Thermasote is a combination of wood and other fibres united in a process that meshes and binds them into a substantial board suitable for exterior and interior walls, plaster base and many other applications in homes, stores, garages and business buildings. It is made $\frac{7}{16}$ in. thick, is strong, durable and excellent as an insulator against both heat and cold.

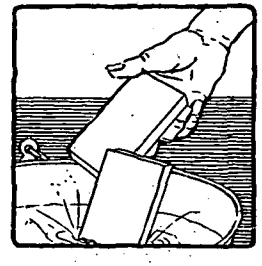


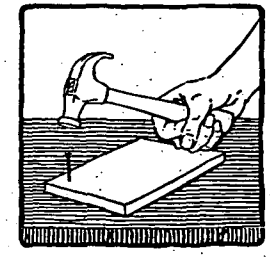
Thermasote withstands exposure and may be worked in many ways. The surface takes paint admirably and may be used in a variety of decorative treatments. It is made in convenient sizes and its use gives assurance that the building will be remarkably warm in winter and cool in summer.

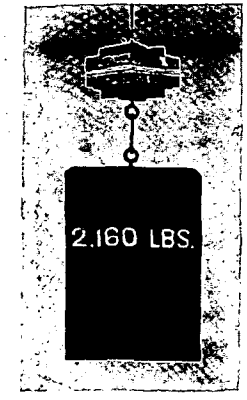
Thermasote may be applied in old houses as well as in new buildings and is particularly effective for lining an attic to stop heat losses through roof. It can be used as siding, sheathing, paneling, etc., and because of its ease of application, is readily used in wood shingle, clapboard, stucco, brick veneer and other popular building wall constructions.

Material	Description	Dimension Standard Sheet	Standard Thickness
Thermasote Building Board	Wood fibre board for interior and exterior constructions.	4′ x 8′ 4′ x 10′ 4′ x 12′ 4′ x 14′ 6′ x 12′ 8′ x 10′ 8′ x 12′ 8′ x 14′	$\frac{7}{16}$ in.









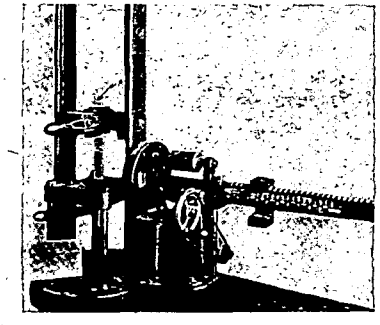
Heat-Resistant Quality

A heat insulation test on Thermasote made by the Armour Institute of Chicago, expressed in British Thermal Units per hour per foot of surface, per degree Fahrenheit, difference in temperature between the surface of the material per inch thickness, showed the coefficiency of heat conductivity per inch thick of 0.37 or for one day or 24 hours 8.98.

An absorption test of Thermasote wholly immersed in water for 24 hours showed the percentage of absorption as only 34.8.

The low moisture absorption percentage means higher insulation against dampness, for it is a well-known fact that as absorption increases insulating value decreases.

Thermasote is widely used as a plaster base. Put on with nail wire mesh over joints, then apply plaster in the regular manner. No lath is necessary. The *tenacious* grip that plaster takes on Thermasote is shown by accompanying illustration. Note that its adhesion supports more than a ton weight.

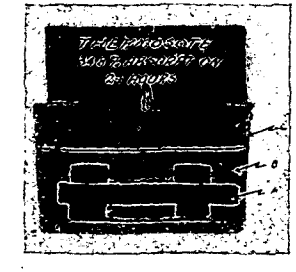


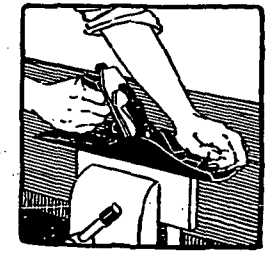
Tensile Strength

Thermasote shown 650 lb. per sq. ft. This is considerably greater than that of any other similar product.

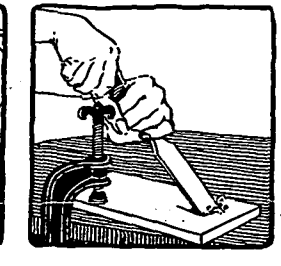
Heating a home when the snow flies and keeping it comfortable when the mercury soars is greatly assisted by using Thermasote in its construction.

Nowadays the whole house must be comfortable, and comfort must be *maintained with least* possible expense. Unless a dwelling is properly insulated against winter's blasts and summer's sun, it will lack a decidedly strong sales factor.









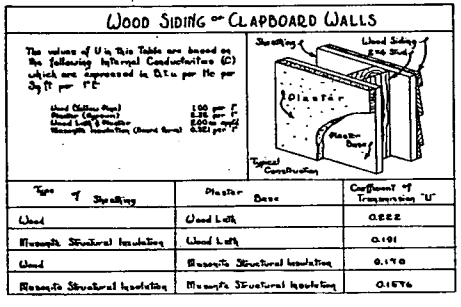
Masonite Corporation

111 W. Washington Street **Chicago, Ill.**

Masonite Structural Insulation and Masonite Presdwood

Pat. No. 1578609-1663503-1663504 1578609-1663505

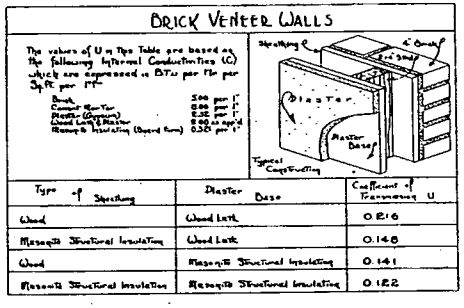
Mills: LAUREL, MISS.



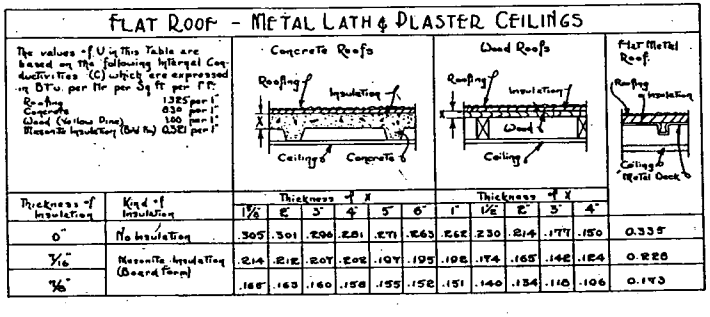
Type of Sheathing	Plaster Base	Coefficient of Transmission "U"
Wood	Wood Lath	0.222
Masonite Structural Insulation	Wood Lath	0.191
Wood	Masonite Structural Insulation	0.170
Masonite Structural Insulation	Masonite Structural Insulation	0.1576

The great insulation value of Masonite is attributable to the cellular formation of the wood fibres from which it is made and to the thoroughness with which those fibres are felted together in the finished board. This also explains the great strength of Masonite Structural Insulation. This insulation is made entirely of fibres obtained by exploding fresh, clean wood chips and it contains no artificial binder of any character. There is nothing in Masonite to break down or disintegrate—it is permanent.

Masonite is used as sheathing on the outside of studs for both heat and sound insulation under wood siding, brick, stone or tile veneer and stucco. It is also used on the inside of studs as a plaster base—and it bonds with the plaster so effectively that an average pull of more than 1000 lb. is required to pull the plaster from one square foot of Masonite Insulating Lath.



Type of Sheathing	Plaster Base	Coefficient of Transmission U
Wood	Wood Lath	0.216
Masonite Structural Insulation	Wood Lath	0.148
Wood	Masonite Structural Insulation	0.141
Masonite Structural Insulation	Masonite Structural Insulation	0.122



Thickness of Insulation	Kind of Insulation	Thickness of X (Concrete Roofs)						Thickness of X (Wood Roofs)					Flat Metal Roof
		1/8"	2"	3"	4"	5"	6"	1"	1/8"	2"	3"	4"	
0"	No Insulation	.305	.301	.296	.291	.271	.263	.256	.230	.214	.177	.150	0.335
1/16"	Masonite Insulating (Board Form)	.214	.212	.207	.202	.197	.195	.198	.174	.165	.142	.124	0.228
1/8"		.166	.163	.160	.158	.155	.152	.151	.140	.134	.118	.106	0.173

In roof decks, it effectively ends preventable heat losses and reduces condensation to a negligible minimum.

Sprayo-Flake Company

Administrative Offices **Milwaukee**

Manufacturers of Sprayo-Flake Material and Equipment



56 South Bay Street **Wisconsin**

Licensed Operators in Principal Building Centers

INSULATION APPLIED BY AIR

Process—SPRAYO-FLAKE insulating process consists of forcing by air prepared flakes of fibrous material previously impregnated with fire resisting agent through a specially constructed gun. As the flakes leave the gun they are coated with spray of atomized adhesive agent (water glass) and projected to the surface to be insulated. The coated fibrous flakes form a blanket of insulation covering all cracks and crevices. It can be applied to practically any surface in any desired thickness.

Development—SPRAYO-FLAKE was conceived by a layman while observing the installation of insulating material in his own home under course of construction. Prompted by a desire to overcome the inefficiency and attendant difficulties involved in installing prepared types of insulating materials, the spray gun method was evolved. Further development proved the soundness of this theory. SPRAYO-FLAKE method in one operation does a most thorough job, it eliminates entirely the labor of cutting, fitting, and nailing.

Further development of the original idea dates back to the year of 1924 when specially designed equipment was perfected to apply SPRAYO-FLAKE. The next step was adoption of an adhesive agent, addition of fire resisting qualities, and vermin proofing which was perfected in laboratories and practical usage in the building field.

Distribution and Service—To assure the highest return per dollar invested in insulation the SPRAYO-FLAKE Co. has adopted a modern economically sound plan of merchandising and distribution. SPRAYO-FLAKE is supplied direct from factory to job through licensed operators. These licensed operators located in principle building centers are insulation specialists, financially responsible, and work on an exclusive franchise basis. Each installation is made by expertly trained mechanics under exacting supervision.

This advanced plan of distribution enables the architect, builder, or owner to know the exact cost of insulation. SPRAYO-FLAKE is always quoted on the basis of unit price per square foot or lump sum bid installed, including labor and material.

Physical Characteristics

The fibrous cellular structure and method of application gives SPRAYO-FLAKE the desired characteristics of the ideal insulation material:

1. **LOW THERMAL CONDUCTIVITY.** 0.25 B.t.u. per hour per square foot per 1 in. thickness per degree temperature differential.
2. **PRACTICABILITY.** Can be applied to practically any surface in any desired thickness. Seals cracks and crevices, calks around window and door frames.
3. **FIRE RESISTANT.** Pre-chemically treated fibrous material plus the sodium silicate binder produces a highly effective fire resisting insulation.
4. **VERMIN PROOF.** Alkali silicate binder and alkaline sulphate impregnation render SPRAYO-FLAKE insulation repellant to vermin.
5. **LIGHT WEIGHT.** Flakey fibrous air cell structure weighs only 4.6 lb. per cubic foot installed.
6. **PERMANENCY.** The fabricated blanket of SPRAYO-FLAKE insulation is held in place securely by employing a sodium silicate cohesive binder. This binder also preserves the fibrous flakes from deterioration. The cohesive properties of sodium silicate have been utilized in the paper making industry for many years.
7. **LOW COST.** SPRAYO-FLAKE insulation is manufactured and applied mechanically in one operation eliminating costly labor involved in cutting and fitting prepared types of materials.
8. **FLEXIBILITY.** SPRAYO-FLAKE is sufficiently flexible to allow for usual expansion and contraction of structural members to which it is applied without impairing its efficiency.
9. **SOUND ABSORBENT.** The cellular structure and resiliency of SPRAYO-FLAKE render it a highly sound absorbent material.

NOTE.—Conductivity and Transmission tests by such authorities as Prof. J. C. Peebles, Armour Institute; Bureau of Standards and Prof. F. B. Rowley of Minneapolis.

Complete Technical Data and Specifications Furnished upon Request

Stewart Inso Board Company

St. Joseph, Missouri

MANUFACTURERS OF



INSO BOARD

Dependable Building Insulation

Standard Building INSO BOARD is a scientifically prepared and moisture proofed building board, made of the strong tough fibres of wheat straw, which are interlaced and compressed to form a strong and force-resisting material. It is moisture and vermin proofed through special processes. Thorough sterilization removes all soluble food content. The long tough wheat straw fibres, strongly interlaced, give it more than the necessary structural strength. It is an excellent sound deadener, being higher in sound insulation value than deadening felts. Thickness—½ in. Average weight—60 lbs. per 100 sq. ft. Width—4 ft. Any length desired.

Thermal Conductivity

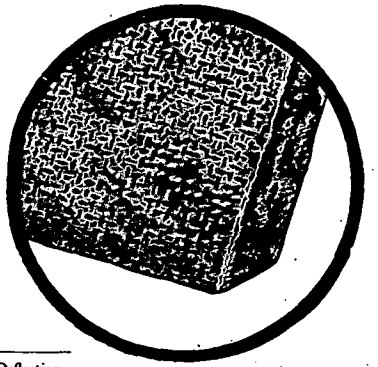
The following tests have been made in accordance with regulations of the National Better Business Bureau and under the personal supervision of Mr. G. F. Gebhardt, Mechanical Engineer of the Armour Institute of Technology at Chicago. Results of these tests prove that INSO BOARD has a higher degree of insulating efficiency than any other structural insulating board on which scientific tests have been made.

FLAT PLATE TEST

Material	Thickness Inches	Density Lb., Cu. Ft.	Heat Conductivity B.t.u. per 1 in. Thick	
			Per Hour	Per Day
Inso Board	0.447	17.0	0.324	7.78

HOT BOX TEST

Material	Thickness Inches	Density Lb., Cu. Ft.	Heat Conductivity B.t.u. per 1 in. Thick	
			Per Hour	Per Day
Inso Board	0.485	16.6	0.25	6.0



TENSILE TESTS

No.	Dimensions Inches	Area Sq. In.	Tensile	
			Actual	Sq. In.
1	2 x 0.488	0.976	350	359
2	2 x 0.480	0.960	300	313
3	2 x 0.490	0.980	340	347
Average				339⅔

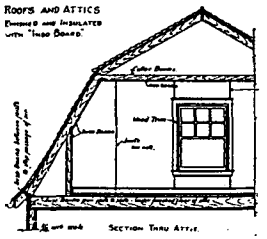
TRANSVERSE TESTS

No.	Dimensions Inches	Span Inches	Maximum Load, Lb.	Deflection Inches
1	6 x 0.500	12	36	1⅜
2	6 x 0.497	12	37	1
3	6 x 0.483	12	38	1¼

PLASTER BOND TESTS

No.	Dimensions of Bonded Surfaces	Area of Bonded Surfaces Sq. In.	Load to Break	
			Actual	Sq. Ft.
1	6" x 6"	36	210	840
2	6" x 6"	36	215	860
3	6" x 6"	36	230	920

The failure of all specimens occurred in the board, no failure between plaster and board.



INSO BOARD is also made in Acoustic Blocks, Railroad Car Insulation and Industrial Board. Specification Book will be sent upon request.

United States Gypsum Company

General Offices

300 West Adams Street, **Chicago**

THERMOFILL

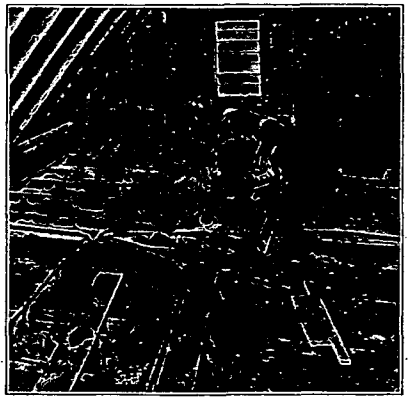
The Dry Fill Insulation

Description:

Thermofill is a fibrous gypsum flake, and is formed by impregnating short pulp fibres with especially processed gypsum. It comes in clean paper bags, and is installed, dry, by being poured in, or on, the area to be insulated. It fills all cracks and crevices, and seals them against the infiltration of wind and the escape of heat.

Thermofill weighs 1½ lb. per square foot per inch of thickness. The average lath and plaster ceiling—such installations of Thermofill will be discussed later—will safely carry twenty times the weight of a 3 in. installation of Thermofill.

Being made of gypsum, Thermofill is fireproof. It does not burn or support combustion. It does not create dust at, or after, the time of installation. Insects and other vermin cannot live in it.



Installing Thermofill between Ceiling Joists

Where Thermofill is Installed:

Thermofill is installed in walls of wood frame construction, behind 2 in. furring strips of masonry construction, and on all types of ceilings. Ceiling installations vary from 2 to 4 in. in thickness, depending on the degree of insulation desired.

Thermofill can be used to insulate old residences. So used it is placed, from the attic, over the ceilings of the rooms below. Where an attic floor is in place, a few boards can be removed, and the Thermofill can be installed in the openings thus made.

Installed in an old house, Thermofill not only will bring the temperatures of the upstairs rooms to a parity with the temperatures of the rooms below, but will also save fuel.

Thermal Conductivity of Thermofill

Density per Cu. Ft.	B.t.u. per Sq. Ft. per 1" per 1°F./Hr.	Authority
18 lb.	0.34	J. C. Peebles
19.8	0.35	Bureau of Standards
24	0.475	J. C. Peebles

Efficiency of Typical Construction, Uninsulated and Insulated

WALLS	Uninsulated	Insulated with 3⅜" Thermofill
Clapboards, paper, sheathing, stud, lath and plaster	0.227	0.095
Brick veneer, paper, sheathing, stud, lath and plaster	0.216	0.082
Stucco, paper, sheathing, stud, lath and plaster	0.257	0.099
CEILINGS		
Lath and plaster—no floor	0.502	.....
Lath and plaster—single floor	0.234	.....
Lath and plaster—no floor—(Insulated with 2" of Thermofill)		0.127
Lath and plaster—no floor—(Insulated with 3" of Thermofill)		0.092
Lath and plaster—no floor—(Insulated with 4" of Thermofill)		0.073

Wood Conversion Company

General Office and Factory at

Cloquet, Minnesota

District Sales Offices:

CHICAGO, ILL., 1320 London Guarantee Bldg. NEW YORK, N.Y., 101 Park Avenue
DETROIT, MICH., 503 Stephenson Bldg. MINNEAPOLIS, MINN., 414 Baker Bldg.
KANSAS CITY, MO., 404 Congress Bldg.

Manufacturers of

Balsam-Wool

House Insulation
***Sound Absorbent**

***Steel Car Insulation**
***Refrigerator Car Insulation**

Also Manufacturers of
***NU-WOOD—the Rigid Insulating Wall Board and Plaster Base**

BALSAM-WOOL Standard Building Insulation is a flexible insulating blanket made from pure wood fibres in fleecy wool form, permanently matted together between two sheets of tough, asphalt-coated kraft paper which render it windproof and waterproof. BALSAM-WOOL contains no animal matter. It will not attract or harbor rats, mice or vermin. It is clean, odorless and sanitary. A Weyerhaeuser product.



Sizes—BALSAM-WOOL is made in two thicknesses, full inch and half-inch, and in standard widths of 17, 25 and 33 in. It comes rolled, wrapped and sealed. Half-inch BALSAM-WOOL weighs 200 lbs. per 1,000 sq. ft. One inch BALSAM-WOOL weighs 320 lbs. per 1,000 sq. ft.

Application—BALSAM-WOOL 17 in. and 25 in. wide is applied between the studs, joists or roof rafters, flanged midway between the sheathing and plaster. BALSAM-WOOL 33 in. wide is applied to the inside face of the studs or joists of frame construction. In solid masonry construction, BALSAM-WOOL is applied to wood strips, with furred out lath and plaster.

*Complete information on request.

Thermal Conductivity

The following hot plate test by Professor J. C. Peebles gives the thermal conductivity of BALSAM-WOOL per square foot, per inch thickness, per degree difference in temperature, per hour, and shows the extremely high insulating value of the material.

Material	Thickness Inches	Density Lbs. Cu. Ft.	Conductivity	
			Per Inch Thick	Per Thickness as Tested
Balsam-Wool	0.63	3.62	.229	.364

Radiation Reduction

In a building properly insulated with BALSAM-WOOL, 25 to 35 per cent less radiation and boiler capacity as well as relatively smaller pipe sizes will be required and the saving is usually enough to pay for the cost of the insulation.

In computing the heat losses from a building and the radiation required, the following coefficients should be used.

TYPE OF CONSTRUCTION	B.t.u. Transmission per Sq. Ft., per Hour, per 1 deg. fahr. Difference in Temperature.		
	Uninsulated*	Insulated** with ½ Inch Balsam-Wool	Insulated*** with 1 Inch Balsam-Wool
Wall: Frame, Wood Siding	0.227	0.122	0.099
Wall: Frame, Stucco on Metal Lath	0.257	0.130	0.105
Wall: Frame, Brick Veneer	0.216	0.118	0.097
Wall: 8 In. Brick with Furring Strips	0.209	0.116	0.096
Ceiling: Lath and Plaster, no Floor	0.502	0.172	0.131
Ceiling: Lath and Plaster, Single Floor	0.234	0.124	0.101
Roof: Wood Shingles on Sheathing Lath and Plaster	0.246	0.127	0.103
Roof: Asphalt or Asbestos Shingles on Sheathing Lath and Plaster	0.259	0.130	0.105

*Taken from A. S. H. & V. E. GUIDE.
**Based on Actual Thickness of ½ in. BALSAM-WOOL.
***Based on Actual Thickness of 1 in. BALSAM-WOOL.

UNIVERSAL GYPSUM & LIME CO.

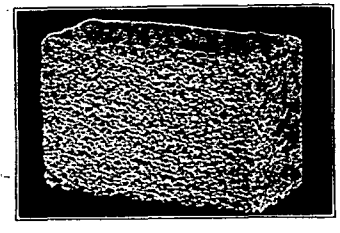
NEW YORK, N. Y., JACKSONVILLE, FLA. Offices: **Chicago, Ill.** FORT DODGE, IOWA, KANSAS CITY, MO.

MILLS—AKRON, N. Y., FORT DODGE, IOWA, ROTAN, TEXAS

INSULEX
GYPSUM INSULATION

Reg. U. S. Patented Office

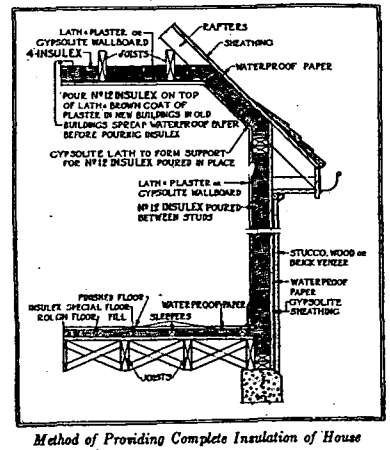
Insulex is a gypsum insulating material for building construction and is used to prevent the passage of heat, cold and sound. When mixed with water **Insulex** powder expands and hardens into a cellular mass in partitions, floor and ceiling spaces. It is especially adapted for use in homes, apartment houses, schools, commercial and industrial buildings where the saving of heat is a vital necessity.



A Block of INSULEX *Showing Cellular Structure*

The use of **Insulex** reduces the size of heating plants and amount of radiation installed so that in estimating the heating requirements of a building using **Insulex** insulation special conductivity factors are required.

Complete A. I. A. Specifications, reports of tests and engineering data on **Insulex** will be furnished on application. Our staff of heating engineers will help solve your problems on reduced radiation.



Method of Providing Complete Insulation of House

BUILDING CONSTRUCTION*

SIDE WALLS (FRAME)	UNINSULATED	INSULATED Filling Space between 2" x 4" Studs with 3⅛" No. 12 INSULEX	
		Lath and Plaster	Gypsolite Plaster Board and Plaster
Clapboard, Paper, Sheathing, Stud, Lath and Plaster	0.227	0.074	0.071
Brick Veneer, Paper, Sheathing, Stud, Lath and Plaster	0.216	0.072	0.069
Cement Stucco, Paper, Sheathing, Stud, Lath and Plaster	0.257	0.076	0.073

SIDE WALL (MASONRY)			By Using 2-Inch Furring Strips and Filling Space with No. 12 INSULEX	
	No Furring Strips	With Furring Strips	Lath and Plaster	Gypsolite Plaster Board and Plaster
Brickwall Wall—Plastered Inside:				
9-in.	0.332	0.209	0.113	0.107
13-in.	0.263	0.179	0.104	0.099
17-in.	0.208	0.152	0.094	0.089
Terra-Cotta Wall—Stucco Exterior—Plaster Inside:				
8-in.	0.273	0.184	0.105	0.100
12-in.	0.193	0.144	0.090	0.087

CEILING		Filling Space between Joists 4-in. with No. 12 INSULEX	
Ceiling Joists, Lath and Plaster. No Attic Floor	0.502	0.083	0.080
Ceiling Joists, Lath and Plaster. Attic Floor	0.234	0.070	0.068

ROOF RAFTER CONSTRUCTION	UNINSULATED	INSULATED Filling Space between Rafter 4 in. with No. 12 INSULEX	
Shingle, Wood on Wood Strips, Rafter, Lath and Plaster	0.246	0.071	0.068
Slate or Tile, Paper, Sheathing, Rafter, Lath and Plaster	0.262	0.072	0.070
Asphalt or Compo, Shingles, Paper, Sheathing, Rafter, Lath & Plaster	0.259	0.072	0.070
Asbestos Shingles, Paper, Sheathing, Rafter, Lath and Plaster	0.259	0.072	0.070

*HEATING CONSTANTS—For use in determining house heating, radiation requirements when insulated with **Insulex** according to Universal Gypsum & Lime Co. specifications.

The figures given are in B.t.u.'s per square foot per hour per degree temperature difference and show heat loss or conductivity. These figures can be used in figuring reduced size of heating plants and radiation required in an **Insulexed** home.

The uninsulated constants are based on those published in the A. S. H. & V. E. GUIDE, 1928. The insulated factors are based on internal conductivity of 0.40 for 12 lb. **Insulex No. 12.**

Builders Iron Foundry

9 Codding Street **Providence, R. I.**

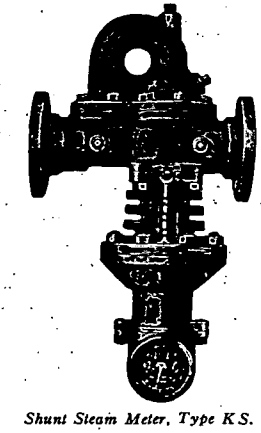
Branch Offices and Representatives

NEW YORK, N. Y.	25 Church Street	PITTSBURGH, PA.	1503 Oliver Building
PHILADELPHIA, PA.	617 Harrison Building	CHICAGO, ILL.	466 Peoples Gas Building
SAN FRANCISCO, CALIF.	Percy Keatinge, 85 Second Street		
LOS ANGELES, CALIF.	Percy Keatinge, c/o Pacific Mfg. Co., 530 West 6th Street		
DALLAS, TEXAS	Morey & Morey, 417 Praetorian Building		
CHARLOTTE, N. C.	Grinnell Co., Inc., P. O. Box 336		
TORONTO, ONT., CAN.	Allen General Supplies, Ltd., 15 Toronto Street		
ATLANTA, GA.	Wm. F. Wilcox, Fourth National Bank Building		
SEATTLE, WASH.	California Filter Co., 1005 Securities Building		
KANSAS CITY, MO.	Terry, Cowan & Smith, Inc., 1005 Davidson Building		
VANCOUVER, B. C., CAN.	Chas. A. Moorehead, c/o R. C. Cooper & Co., Ltd., 615 Pender Street, West		
BUENOS AIRES, ARGENTINA, S. A.	Major Geo. C. Robertson, 760 Avenida de Mayo		

Builders of the Venturi Meter, Diaphragm Meter, Shunt Steam Meter, Etc.

SHUNT STEAM METER

The Shunt Steam Meter fills the need for a low priced, practical steam meter which is easily installed and accurate over a wide range. It is used to advantage in measuring steam sold or in checking the distribution of steam (also air or gas) to various buildings, departments, machines or processes. Illustration shows the complete Meter. An orifice in the main line of flow deflects a portion of the steam through nozzles and against the turbine located in the shunt circuit out of the main line of flow. The turbine shaft extends through a housing into a condensation chamber below the main line. A damping fan attached to this shaft operates under water, keeping the speed low and eliminating bearing trouble. Magnetic drive between this chamber and the counter mechanism protects the latter from moisture. The meter is installed as a unit in 2, 3 and 4-in. lines. For larger size mains a small meter is installed in a by-pass line around an orifice in the main line.



Shunt Steam Meter, Type K S.

	Steam Pressure Lbs. per Sq. In. Gauge	Approximate Measuring Range	Rated Capacity of Saturated Steam Lbs. per Hour		
			2" Meter	3" Meter	4" Meter
Low Pressure Meters	0	10-1	610	1410	2530
	5	10-1	810	1880	3350
	10	10-1	1000	2340	4170
	15	10-1	1200	2750	4750
	20	10-1	1380	2950	5150
	30	11-1	1650	3400	5850
	40	12-1	1800	3750	6450
	50	13-1	2000	4050	7000
Standard Meters	50	10-1	2650	6000	10600
	75	10-1	3650	8250	14600
	100	11-1	4150	9500	16600
	125	12-1	4600	10500	18300
	150	13-1	5000	11400	20000
	175	14-1	5350	12300	21400
	200	15-1	5700	13000	22700
Extra Heavy Meters	225	15-1	6000	13700	24000
	250	15-1	6300	14400	25200
	275	15-1	6600	15200	26500
	300	15-1	6900	15700	27500

Table shows rated capacities only. Minimum Capacities equal one-tenth tabulated quantities. Where Approximate Measuring Range exceeds 10-1 the Meter has that overload capacity.

Bulletin 234 gives complete information.

The Higgin Manufacturing Co.

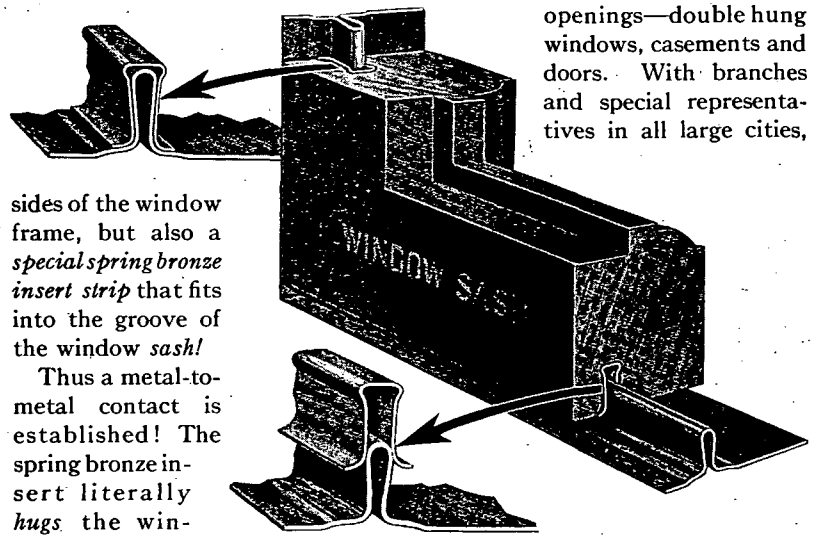
Newport, Ky.

Manufacturers of Metal Weather Stripping for Windows and Doors

Representatives in Principal Cities

HIGGIN ALL METAL Weatherstrips

Higgin all-metal weatherstrips are distinctly different from those of other manufacturers. HIGGIN not only has the usual metal strip which is fitted to the four sides of the window frame, but also a *special spring bronze insert strip* that fits into the groove of the window *sash!*



Thus a metal-to-metal contact is established! The spring bronze insert literally *hugs* the window, and provides absolute protection against drafts, dust, dirt, and irritating rattles. Even though the window sash shrinks (as so often happens) the metal-to-metal contact remains totally uneffected—cold air positively cannot gain entrance. The efficiency of the heating system is increased 25 per cent and upwards!

THE HIGGIN ORGANIZATION, backed by 35 years of constant progress, is fully prepared to weatherstrip all types of openings—double hung windows, casements and doors. With branches and special representatives in all large cities, HIGGIN offers you maximum service and co-operation *plus* a brand of weatherstripping without equal.

If your files do not already contain full information on HIGGIN weatherstrips, a word from you will bring same.

The Higgin Manufacturing Co.

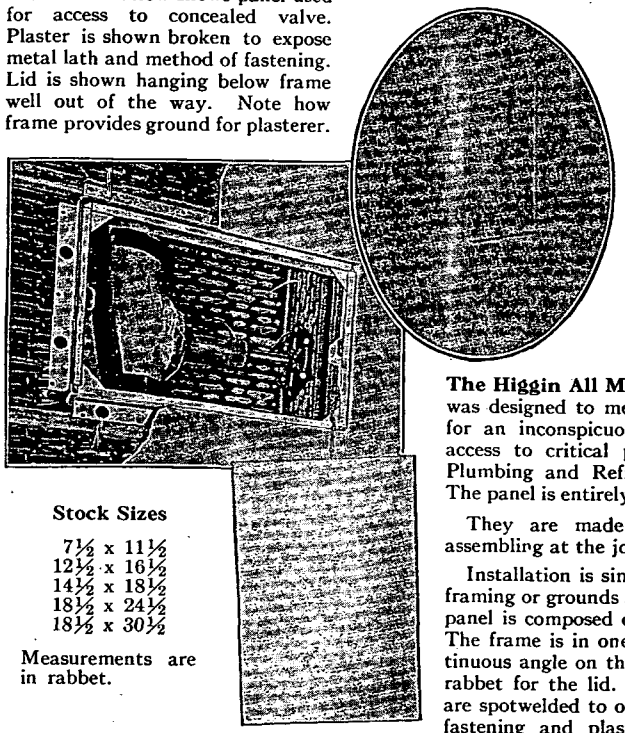
Newport, Ky.

Manufacturers of Metal Access Panels for Heating and Plumbing Systems

Representatives in Principal Cities

HIGGIN ALL METAL Access Panel

Illustration below shows panel used for access to concealed valve. Plaster is shown broken to expose metal lath and method of fastening. Lid is shown hanging below frame well out of the way. Note how frame provides ground for plasterer.



(IN OVAL) Lid is shown in place. Note how inconspicuous the panel is.

Stock Sizes

7½ x 11½
12½ x 16½
14½ x 18½
18½ x 24½
18½ x 30½

Measurements are in rabbet.

The Higgin All Metal Access Panel was designed to meet a pressing need for an inconspicuous flush panel for access to critical places in Heating, Plumbing and Refrigerating systems. The panel is entirely of metal.

They are made as a unit. No assembling at the job.

Installation is simple and no special framing or grounds are necessary. The panel is composed of a frame and lid. The frame is in one piece with a continuous angle on the inside, forming a rabbet for the lid. Perforated angles are spotwelded to outside of frame for fastening and plaster key. On the smaller panels friction catches hold the lid in place. For the larger sizes, retaining clips and special cam fasteners are used. Concealed hinges may be provided if desired in place of the retaining clips. Panels may be installed in walls faced with plaster, tile or marble. They can be painted, decorated or papered over.

Higgin All Metal Access Panels are ideal for use in Hospitals, Apartment Houses, Hotels, Residences, Offices and other Buildings.

WRITE FOR COMPLETE DESCRIPTIVE LITERATURE

GENERAL ELECTRIC COMPANY

SCHENECTADY, N. Y.

Sales Offices in Principal Cities

Motor Drive and Control

For Heating, Ventilating and Air Conditioning Systems

Methods of Drive

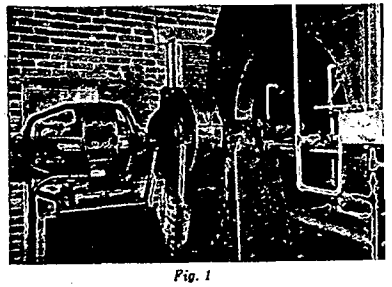


Fig. 1

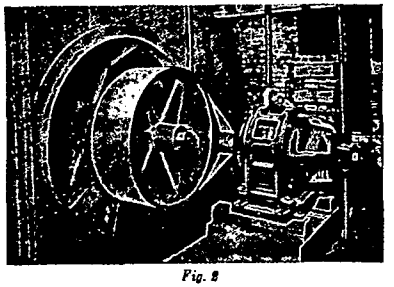


Fig. 2

Fig. 1. Silent chain drive can frequently be employed to advantage, with a lowering of the motor cost as compared with direct-connected drive. The illustration shows a 85 hp., 500/900 r.p.m., Type CD, adjustable speed, motor driving an American Blower Fan at the Portland (Oregon) Journal Building. The chain drive is enclosed in an oil-tight housing.

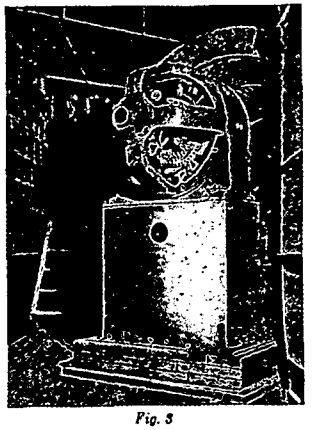


Fig. 3

Fig. 2. "Texrope" drive makes possible the placing of the motor very close to the fan pulley, and saves space. The illustration shows a 50 hp., 850 r.p.m. motor driving a Buffalo fan. The maximum fan speed is 140 r.p.m.

Fig. 4. With fans of moderate size driven by alternating-current motors, the simple belt drive is efficient and economical. This illustration shows a Type KT, 3 hp., 860 r.p.m., constant speed motor controlled by a CR7005 magnetic switch, operating a Buffalo fan in the Plaut Store, Newark, N. J.

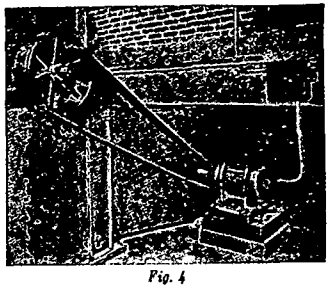


Fig. 4

Fig. 5. The direct-connected, slow-speed direct-current motor has long been a standard drive for ventilating and exhaust fans in large buildings. It is quiet and compact in operation, and has the lowest possible maintenance for a long period of years. The illustration shows a Type CD, 15 hp., slow-speed, adjustable speed motor driving an American Blower fan at the Detroit Masonic Temple.

Fig. 6. The center distances on a belt drive can be shortened by using the "Lenix" idler to insure a larger arc of contact at the motor pulley. The illustration shows a 10 hp., Type MT, slip-ring induction motor driving a fan at the Washington High School, New Rochelle, N.Y.

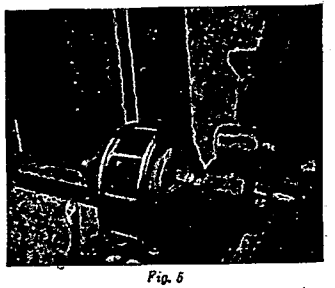


Fig. 6

This Company will gladly assist in the solution of any electrical problem in relation to heating and ventilation

Motor Drive and Control

For Heating, Ventilating and Air Conditioning Systems

Controllers for Use with Varying Speed, 3- or 2-phase, Alternating-Current, Slip-Ring Motors for Driving Fans

Remote Indicating Control

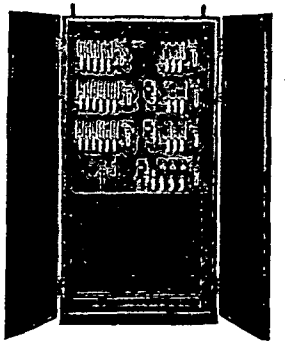


Fig. 1.—CR7761-F1, 20-50 Hp.

H.P.	Dimensions in Inches (Approx.)			Net Weight in Lb. (Approx.)
	Height	Width	Depth Doors Open 90°	
5- 7½	*67½	35½	49⅛	580
10–15	*67½	35½	49⅛	600
20	*67½	35½	49⅛	870
25	*67½	35½	49⅛	870
30	*67½	39½	53⅛	1050
40	*67½	39½	53⅛	1130
50	*67½	39½	53⅛	1200

*All sizes mounted on 64-in. angle supports.

Equipment includes one CR7761-F1 control panel, one BS-15-F four-speed indicating station, one BS-31-A start-safe-run station and one CR1924, 3-pole, fused switch. Dimensions of BS-15-F are 8½ in. by 15¾ in. Sizes 5–15 hp. have self-contained resistors. Larger sizes have separate resistors.

Four Speeds—CR7761-F1

Remote indicating control, four speeds, operated by remotely located push-button station with bull's-eye lights of different colors indicating speed selected or attained. 5–50 hp.

CR7761-F1 enclosed contactor panel includes four speed-controlling or accelerating contactors with three relays. Remote located push-button station BS-15-F has four speed buttons marked (1) Slow Speed, (2) Second Speed, (3) Third Speed, (4) Full Speed, and one "stop" button. On pressing any "speed" button the motor accelerates automatically to that speed and the corresponding bull's-eye is illuminated. Speed can be changed while running to any other value by pressing button corresponding to speed desired. An additional control station BS-31-A with three buttons, "start," "safe," and "run," may be provided adjacent to the motor to start the equipment at the motor for test purposes. When the "safe" button is pushed the equipment is not only stopped but cannot be started from the remote indicating station. The "run" button on the BS-31-A station adjacent to the motor is pressed to release the "safe." When started by the BS-31-A station adjacent to the motor, the motor can be run at slow speed only. If it is desired to arrange this controller so that the motor can only be started in the fan room, add a CR7002 and a BS-79-J Start-Stop station. With this arrangement the BS-31-A station will not be required. Speed control and stopping may be secured from the remote station as before.

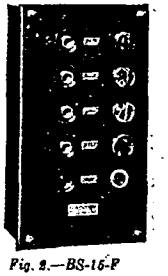


Fig. 2.—BS-15-F

Use with these Controllers Type MTB Quiet Operating Slip Ring Motors

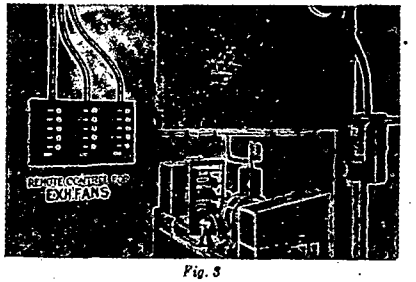


Fig. 3

Installation of 3 BS-15-F, Remote Indicating Control Stations for CR7761-F1 Controllers operating Exhaust Fans in the Pent House of the Salaam Temple, Newark. At right is shown a Type MT Motor belted to Supply Fan and Controlled by a CR7764 Controller

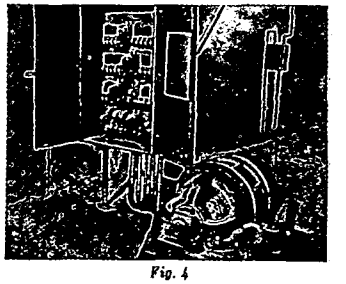


Fig. 4

Installation of Type MT Motor belted to Exhaust Fan at Salaam Temple, Newark. Motor is controlled by a CR7761-F1 Remote Indicating Control Panel operated from a Remote Point by one of the Control Stations shown in Fig. 2

This Company will gladly assist in the solution of any electrical problem in relation to heating and ventilation

United States Ozone Company

Engineers — Manufacturers — Chemists

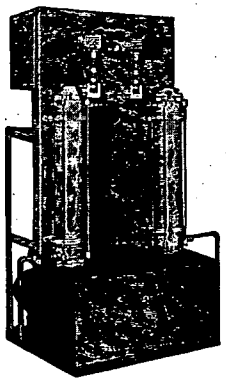
Pacific Coast
MONTGOMERY BROTHERS
61 Fremont Street
SAN FRANCISCO

500 North Dearborn Street
Chicago, U.S.A.

Canada
DARLING BROTHERS, LTD.
140 Prince Street
MONTREAL

PRODUCTS

Complete Ionizing and Ozone producing Plants for all Purposes



Multiple Type
U. S. Controlled Ozonizer

Controlled Ozone Service

We maintain well equipped Chemical Laboratories for the scientific solution of problems, both of a general and specific nature. Our Research Staff and Engineers will gladly consult with you. This service entails no obligation.

For General Ventilation

we provide two types of assembly. The Type TU, United States Ionizer is a self-contained unit, all apparatus being mounted on one base, and is built for requirements up to 120,000 c.f.m.

Where there is a multiplicity of fans, all operated quite independently, we provide our type TM Assembly, which comprises a number of Ionizer units mounted on a common base and employing a common blower and dehydrator.

For Cold Storage Plants

we provide United States Controlled Ozone Apparatus for maintaining the air pure, and fresh, oxidizing odors and inhibiting mold growth, etc.

For Water Purification

we provide United States Ozone and other Apparatus for treating potable waters, destroying all pathogenic bacteria, odors and tastes, particularly the odor and taste of chlorine. Special attention is given to SWIMMING POOLS.

Stockham Pipe & Fittings Co.

Birmingham, Alabama

Warehouses: BOSTON NEW YORK CHICAGO LOS ANGELES

PIPE FITTINGS

Cast Iron — *Screwed — Flanged Drainage*

Malleable — *Standard—Extra Heavy Oil Country Malleable*

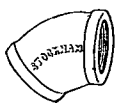
Electric Cast Steel — *Flanged Screwed*

There are over 7,500 patterns in the complete Stockham line. Every pipe fitting requirement for gas, water, steam, oil or air is met by Stockham. Manufactured to a high standard, strength far in excess of probable strain, uniform walls, clean, perfect threads, smooth inner and outer surfaces; always inspected and tested more rigidly than generally accepted standards require. Accuracy is the keynote in Stockham manufacture that makes Stockham Fittings dependable for every pipe line service.



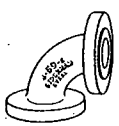
CAST IRON FITTINGS
Screwed Flanged Drainage

Made according to the American Standard. Accuracy in pattern, accuracy in proportioning materials, accuracy in melting, accuracy in molding, accuracy in finishing, accuracy in inspecting and testing.



MALLEABLES
Regular, Extra Heavy and Oil Country

All Stockham Malleables are made according to the quality standard which distinguishes all Stockham fittings. Annealing under definite temperature control which gives ductility, uniform structure and high strength with great resistance to shock and strain.



CAST STEEL
Flanged Fittings and Flanges.

Conform to the American Standard. Walls are 3/16 in. in excess of American Standard Requirements. Regular in outline; conformity to patterns; ample fillets well rounded. Meet specifications of the *American Society for Testing Materials.*

Every fitting hydrostatically tested before shipment. Exceptionally smooth inner and outer surfaces; accurate facings and fine appearance. Made for pressures of 150, 300, 400, 600, 900 and 1350 lb. and for temperatures according to the American Standard.



CAST STEEL
Screwed Fittings.

Every needed design and size. Same quality standard as Flanged Fittings and Flanges. Accurate threads, accurate alignment, smooth inner surfaces. Strength far in excess of probably strain.

Descriptive Catalogs on request.

STOCKHAM FITTINGS

Are sold by leading wholesalers

The Heating and Ventilating Magazine

MEMBER AUDIT BUREAU OF CIRCULATIONS

386 Fourth Avenue, New York

Chicago Office: 705 Builders Building



A Monthly Journal of Engineering Progress

Subscribed for and read by progressive heating and ventilating engineers and contractors, *The Heating and Ventilating Magazine* is regarded by them as the publication of recognized engineering authority in their industry.

Advertisers of heating and ventilating equipment find *The Heating and Ventilating Magazine* to be a most economical and practical medium to reach the men who specify and install the worthwhile heating and ventilating jobs throughout the country.

Sample copies, rate cards, circulation statements and market information upon request.

Subscription Price $2.00 per year

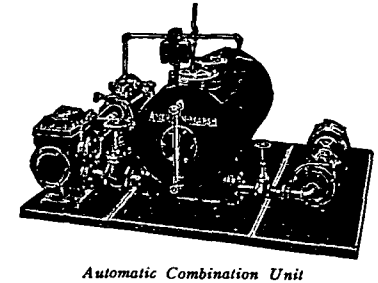
American Steam Pump Company

Plant and General Offices: **Battle Creek, Michigan**

NEW YORK: 17 Battery Place
CHICAGO: 926 Monadnock Bldg.

Sales and Service Agencies Throughout the World

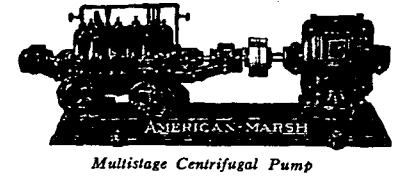
Manufacturers of High Grade Centrifugal and Steam Pumps of All Approved Types to Meet Every Industrial and Public Building Requirement



Automatic Combination Unit

American-Marsh Condensation Units:—Combination unit shown above is an exclusive American-Marsh development extensively used for heating systems where there is wide variation in steam pressure between day and night service. When pressure falls below 15 lb., motor driven pump starts automatically and keeps lines open until enough pressure is again generated to operate steam pump. Economical unit insuring rapid heating on cold mornings. Bulletin 58.

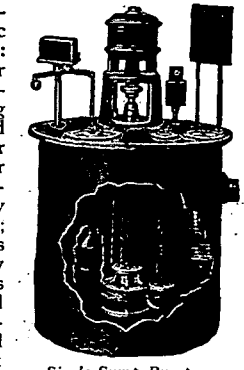
Condensation units equipped with either steam or centrifugal pumps are also furnished in sizes covering all requirements. Bulletins 27, 32 and 52.



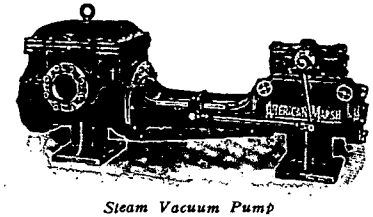
Multistage Centrifugal Pump

American-Marsh Centrifugal Pumps:—Built single or multistage, single or double suction, with split or solid cases. Adaptable for air washer service, pressure boosting, boiler feed, as fire pumps, for general service, etc. Designed for any type of drive. Dependable and highly efficient. Large range of sizes. Bulletins 25, 33, 38, 44 and 53.

American-Marsh Electric Sump Pumps:—Designed for automatic operation, elevating sewage and drainage to sewer levels, for cellar drains, etc. Current used only when pump runs; pump always submerged ready to start. Sizes to handle all jobs. Simple design for faithful service without attention. Also built as duplex units, similar in construction except that two complete pumps are mounted on one cover plate. Bulletin 41.



Single Sump Pump installed in basin



Steam Vacuum Pump

American-Marsh Vacuum Pumps:—Standard equipment includes bronze fittings throughout. Designed for all vacuum heating needs with sizes to handle up to 200,000 sq. ft. radiation. Motor driven if desired. Bulletin 24. Steam pumps also built for boiler feed and general service.

Guarantees and Engineering Service:—Every pump is rigidly tested, and is guaranteed to meet conditions specified. It is further guaranteed against any defects in material and workmanship. Write for the co-operation of our engineers. Our forty years' experience is at your disposal.

Ames Pump Company, Inc.

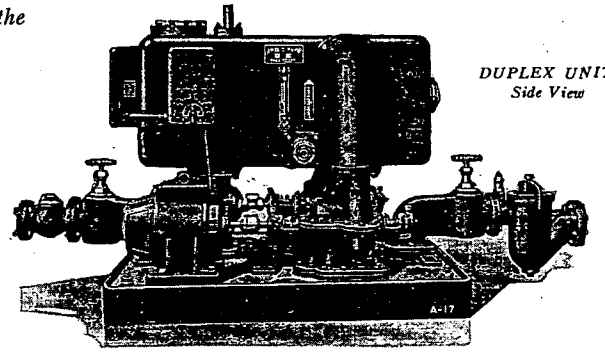
Division of STATEN ISLAND SHIPBUILDING CO.

90 West Street, New York, N.Y.

How to Specify the

AMES Pump

The Pump with a THREE Year Guarantee



DUPLEX UNIT
Side View

VACUUM PUMP—Furnish and erect in space provided by engineer's plans and in accordance with manufacturer's drawing to be approved by the engineer:

( ) Size No. ( ) *Single *Duplex AMES VACUUM HEATING PUMP with Automatic and Manual Control.

Each pump shall be of the Horizontal Split-Case, Multi-Rotor, Centrifugal Type, fitted with bronze internal parts, bronze split stuffiing box glands, and Monel Metal shaft with double row deep groove ball bearings, direct connected through all metal lubricated flexible coupling to:

( ) H.P. ( ) Current ( ) Volt ( ) Phase ( ) Cycle, 40 deg. cent. Ball Bearing Motor.

Each pump shall have a rated capacity of ( ) square feet of equivalent direct radiating surface with a water capacity of ( ) gallons per minute when discharging against ( ) lb. pressure at the unit discharge nozzle. It shall also be capable of maintaining five (5") of mercury (referred to 30" barometer) with condensate at 200° F. when connected to a heating system reasonably free from leaks and deliver same, regardless of temperature, to the boiler.

A complete unit is to be supplied to include pump, motor, cast iron receiver and air separator tank, protected water gauge glass, compound gauge, thermometer, vacuum breaker, discharge check valve, and self-cleaning strainer.

The unit shall be assembled complete with pump, tank and motor mounted on one heavy cast iron base having raised edge at top, screened drain pocket tapped for drain connection, foundation grout holes and levelling bolts.

Suction, discharge, and air vent shall be provided with companion flanges, bolts, nuts, and gaskets.

Dual Electric Control shall be included and consist of *Vacuum Regulator* with *On* and *Off Switch*, and *Float* with *Float Switch* controlling an *Automatic Starter*. Starter shall also be equipped with *Manual Control* to permit *Continuous Operation*. All equipment shall be enclosed, wired and conveniently mounted on receiving tank by the Pump Manufacturer.

*Specify SINGLE or DUPLEX.

3 to 25 in. Vacuum — STANDARD RATINGS — 10 to 40 lb.

Size No.	Sq. Ft. Equivalent Direct Radiation Surface	Equivalent Gal. per Min. at ½ lb. per Sq. Ft. Hr.	Pump Capacity Gal. per Min. at 180 Deg. Fahr.	Air Capacity at 10 in. Vacuum		Receiver Capacity	Motor Horsepower	
				Cubic Feet per Minute	Orifice Diameter	Total Gallons	10 lb.	20 lb.
†5	5,000	3	8	3	1/8	24	3/4	1
†8	8,000	5	11	5	5/64	30	1	1
12	12,000	8	17	7	5/32	30	1	1½
16	16,000	10	22	9	3/16	40	1½	2
26	26,000	17	35	15	1/4	50	2	3
40	40,000	26	60	19	5/32	65	3	5
65	65,000	43	90	34	3/8	87	5	7½
100	100,000	66	140	50	7/16	100	7½	10
150	150,000	100	200	80	9/16	150	10	10

Data for high pressure furnished on application.

†*Nos. 5 and 8, illustrated in Bulletin No. 53 F. All other sizes in Bulletin No. 52 F. Mailed upon request.*

Buffalo Steam Pump Co.

Buffalo, N. Y.

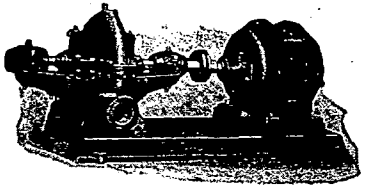
Branch Offices

NEW YORK, N. Y.	Room 1110, 39 Cortlandt St.	DALLAS, TEX.	601 Construction Bldg.
PHILADELPHIA, PA.	1302 Land Title Bldg.	ST. LOUIS, MO.	906 Chemical Bldg.
BOSTON, MASS.	10 Milk St.	CINCINNATI, OHIO.	604 Mercantile Library Bldg.
CLEVELAND, OHIO.	368 Rockefeller Bldg.	MINNEAPOLIS, MINN.	459 N. W. National Life Bldg.
PITTSBURGH, PA.	927 Union Trust Bldg.	LOS ANGELES CALIF.,	c/o Larimer & Lauer, 1824 S. Hope St.
DETROIT, MICH.	Coon-DeVisser Co., 2051 W. Lafayette Blvd.	CHARLOTTE, N. C.	J. W. Fraser Co., P. O. Box 376
CHICAGO, ILL.	562 W. Washington Blvd.	NEW ORLEANS, LA.	Woodward Wight Co.
WASHINGTON, D. C.	418 Washington Loan and Trust Bldg.	SAN FRANCISCO, CALIF.	1006 Flatiron Bldg.
		SEATTLE, WASH.	303 Alaska Bldg.

CANADIAN BLOWER AND FORGE CO. ..... Kitchener, Ont.

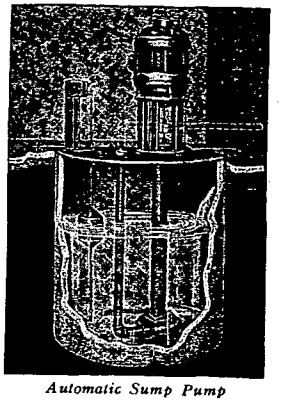
PRODUCTS

Centrifugal Pumps For All Purposes—Single and Double Suction, Single and Multistage, Horizontal and Vertical. Steam Pumps—Duplex and Simplex, Inside Packed and Outside Packed. Vacuum Pumps and Condensers.



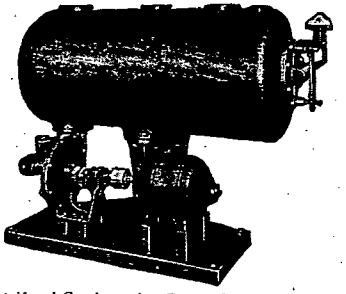
Class "S" Double Suction Centrifugal Pump

Horizontally divided casing. Extensively used with air washers, and for circulating systems and booster service.



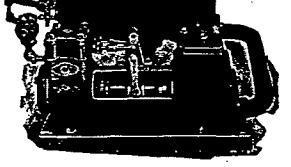
Automatic Sump Pump

Self contained. Ball bearing thrust.



Centrifugal Condensation Return Pump and Receiver

Also built vertical with receiver pit. Especially adapted for low pressure boilers. Automatic in operation.



Duplex Steam Pump and Receiver

Entirely automatic. Can be furnished for high or low boiler pressure.

COMPLETE CATALOGS FURNISHED UPON REQUEST

Chicago Pump Company

Office and Works

2330 Wolfram Street — **Chicago, Ill.**

QUALITY CENTRIFUGAL PUMPS, Condensation, Sump, Vacuum, Sewage, House Circulating, Fire, Pneumatic, Electric Cellar Drainers, and the Automatic Alternator.

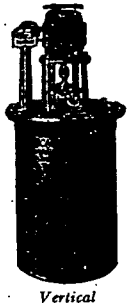
List of Representatives

ARIZONA,
Phoenix, J. W. Ladlow
ALABAMA,
Birmingham, C. P. Leibold
CALIFORNIA,
Los Angeles, Smith Booth Usher Co.
San Francisco, J. A. Lardie
COLORADO,
Pueblo, M. R. Schwer & Co.
Denver, A. Wallace & Co.
CONNECTICUT,
Hartford, Boiler Equipment Co.
D. C.,
Washington, W. L. Ticer
FLORIDA,
Coconut Grove, Ozanne-Magruder Co.
Jacksonville, G. E. Osgood
Tampa, H. G. Carter
GEORGIA,
Atlanta, J. R. Whitman
Savannah, Bergen & Peck
ILLINOIS,
Peoria, C. E. Kallister Co.
INDIANA,
Fort Wayne, Domestic Sales Co.
Indianapolis, W. P. Whittington Co.
IOWA,
Des Moines, E. B. Carr
Sioux City, Wigman Co.
Davenport, A. R. Boudinot
KANSAS,
Wichita, J. M. O'Connor
KENTUCKY,
Louisville, Wallace Hoeing,
LOUISIANA,
New Orleans, F. H. Chisholm
MARYLAND,
Baltimore, Chicago Pump Co.
MASSACHUSETTS,
Boston, Monahan Pump Equip. Co.
MICHIGAN,
Detroit, Chicago Pump Co.
Grand Rapids, C. H. Alexander
Saginaw, R. R. Kimble
MINNESOTA,
Minneapolis, Cash Co.
MISSISSIPPI,
Jackson, Paine Machinery Co.
MISSOURI,
Kansas City, Industrial Power Equip. Co.
Springfield, J. B. McCarty
St. Louis, Foster Mechanical Equip. Co.
MONTANA,
Butte, Sullivan Valve & Engr. Co.
NEBRASKA,
Lincoln, Cornell Supply Co.
Omaha, H. A. Campbell
NEW JERSEY,
Newark, J. M. Chipman
NEW YORK,
Buffalo, Bushnell-Felton, Inc.
New York, Chicago Pump Co.
Rochester, R. C. Schwars
Utica, H. F. Bantham
NORTH CAROLINA,
Charlotte, Amer. Machinery Equipl. Co.
OHIO,
Cincinnati, C. R. Lingo Engr. Sales Co.
Cleveland, Chicago Pump Co.
Columbus, J. T. Seiders
Toledo, M. C. Griffin
OKLAHOMA,
Oklahoma City, Federal Steam Spec. Co.
OREGON,
Portland, P. W. Beggs
PENNSYLVANIA,
Philadelphia, Culbert-Whitby
Pittsburgh, F. W. Rockstraw Co.
SOUTH CAROLINA,
Greenville, James McCabe
TENNESSEE,
Chattanooga, Southern Sales Co.
Knoxville, Morris Bradt
Memphis, C. L. Ahler
Nashville, Southern Sales Co.
TEXAS,
Amarillo, Clowe & Cowan
Dallas, Smith & Whitney
Houston, Dalton-Heyne Co.
McAllen, H. L. Draper
San Antonio, Dalton-Heyne Co.
UTAH,
Salt Lake City, E. G. Dewald
VIRGINIA,
Richmond, Virginia Equip. & Supply Co.
WEST VIRGINIA,
Charleston, H. DeB. Miner
WISCONSIN,
Milwaukee, Swisher Maurer & Co.
WASHINGTON,
Seattle, Heating Service Co.
Spokane, W. B. Starky

VERTICAL CONDENSATION PUMP AND RECEIVER

The vertical condensation pump and receiver is designed particularly to collect the return from heating coils, etc., that come back below the floor level. No concrete pit is required, the unit being adaptable to ground installation, thus using a minimum of floor space. ASK for BULLETIN 133.

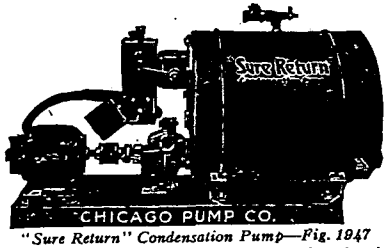
Unit No.	Maximum Sq. Ft. Direct Radiation	Lbs. Press. Pump will Disch. Against	Horsepower Motor Furnished	Capacity Pump in Gals. per Min.	Dia. Receiver, In.; also Floor Space
1650	3,000	10	½	5	24
1651	"	17	¾	"	"
1652	"	22	1	"	"
1654	6,000	10	½	10	24
1655	"	17	¾	"	"
1656	"	22	1	"	"
1658	10,000	10	½	15	24
1659	"	17	¾	"	"
1660	"	22	1	"	"
1662	15,000	14	¾	21	24
1663	"	18	1	"	"
1665	25,000	12	¾	35	30
1666	"	16	1	"	"
1668	40,000	10	¾	55	30
1669	"	14	1	"	"
1670	"	21	1½	"	"



Vertical Condensation Pump
Fig. 1940

HORIZONTAL CONDENSATION PUMP AND RECEIVER

Horizontal condensation pumps and receivers are designed for capacities up to 150,000 sq. ft. of direct radiation and boiler pressures to suit any job. All units are mounted on one base and are assembled at the factory. Simple construction, quiet operation, and low operating costs are a few of the outstanding features.

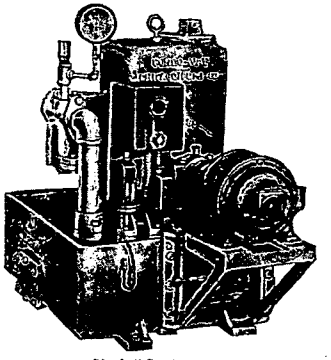


"Sure Return" Condensation Pump—Fig. 1947

The "Sure Return" condensation pump and receiver is especially designed for low and medium capacities and boiler pressures up to 10 lb. All parts are standard and interchangeable. Delivery can be made on this unit in 24 hours. Ask for Bulletin 131.

AUTOMATIC ALTERNATOR.—*Provide a Chicago Pump Company's Automatic Alternator which will automatically transfer the operation from one pump to the other. This alternator will also start the second pump in the event of the failure of the first pump, or will cause both pumps to operate if necessary.*

"CONDO-VAC" VACUUM CONDENSATION PUMPS



Single "Condo-Vac"
Fig. 1990

For the efficient operation of a vacuum heating system where steam must be made to circulate quickly throughout the system, and where the condensate must be returned as quickly as possible to the boiler, the "Condo-Vac" has been highly recommended.

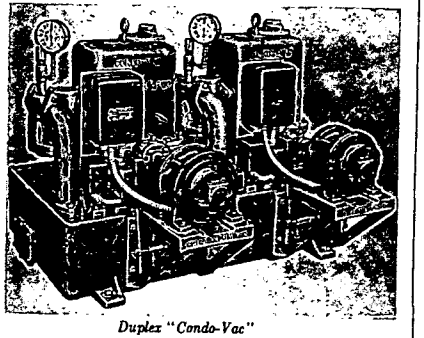
Many "Condo-Vacs" now giving 100 per cent service attest to its efficiency.

The "Condo-Vac" pump is completely bronze fitted, having shaft, rotor, impellers, wearing rings, and impeller and rotor nuts of bronze. This is the same construction as the well known "Chicago" D-Type pumps which are noted for their long life and splendid wearing qualities.

The Receiver of the "Condo-Vac," which also serves as a base, is made of cast iron. Several ribs and post supports give this receiver great strength and assure its vibrationless rigidity when the pump is in operation. The construction of the receiver eliminates the necessity of a special foundation for the pump and forms an ideal base for the pump proper. Cleanout plates are furnished for front and back of receiver and afford adequate means of cleaning the receiver when necessary. A drain is provided for the depression on the top of the receiver.

A heavy cast iron base carries the motor and is adjustable for various motor heights—base provides plenty of ventilation for motor.

The new "Condo-Vac" is inexpensive to install as no special foundation is necessary. The receiver is heavy and flat, and is altogether adequate to serve as a solid base. All piping and wiring in the unit itself is done at the factory.



Duplex "Condo-Vac"
Fig. 1981

ARCHITECTS' SPECIFICATIONS DUPLEX "CONDO-VAC"

Furnish and install where indicated on plans, a duplex "Condo-Vac," centrifugal condensation and vacuum return line pump as manufactured by the Chicago Pump Company. This unit shall be a complete duplex pump mounted on one cast iron receiver together with all apparatus necessary for duplex automatic vacuum and float switch control.

Each pump shall have a capacity of ..... sq. ft. of direct radiation and shall have a pressure of ..... lb. at the pump discharge.

Cast iron receiver shall be so arranged that inlet will not be more than 12 in. from the floor. Pump casing shall be horizontally split. Suction strainer shall be placed between vacuum pump and receiver. Each pump shall be equipped with two out-board ball bearings.

Control apparatus shall include two enclosed, fused, main line switches, two enclosed float switches, two enclosed, automatic, vacuum switches, two manual vacuum cut out switches, and two enclosed automatic starters providing overload and low voltage protection. Each unit shall be controlled by its own vacuum switch and float switch, and piping and wiring shall be so arranged that either unit can be operated independent of the other.

All wiring and electrical connections between motors and control apparatus will be made when equipment is assembled at the factory. The entire pumping equipment is to be shipped from the factory in a complete unit, leaving only wiring between electrical service and motor and piping connections between inlet to receiver and discharge of pump to be done after pump has been shipped.

"CONDO-VAC" TABLES

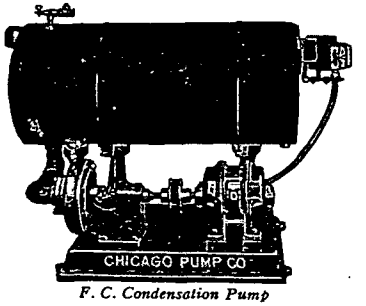
For 10 lb. Pressure at 1720 r.p.m.

Unit No.	Sq. Ft. Direct Radiation	H.P. Motor for 10 lb. Pressure	Air Cap.—C.f.m., 10" Vacuum	Water Pump Capacity, G.p.m.	Size Return Inlet in Inches	Pump Discharge in Inches	Approx. Floor Space in Inches
2601	8000	1	5	12	2	1¼	48x56
2602	16000	1½	10	24	3	1¼	56x60
2603	26000	2	16	39	3	1½	60x62
2604	40000	3	21	60	4	2	66x62
2605	65000	5	36	96	4	2	.....

For 20 lb. Pressure at 1720 r.p.m.

2609	8000	1½	5	12	2	1¼	48x56
2610	16000	2	9	24	3	1¼	56x60
2611	26000	3	15	39	3	1½	60x62
2612	40000	5	19	60	4	2	66x62
2613	65000	7½	34	96	4	2	.....

F. C. CONDENSATION PUMP



F. C. Condensation Pump
Fig. 1931

The F. C. or Float Controlled type condensation pump and receiver is designed for low, medium and high boiler pressures and capacities up to 150,000 GPM. Bulletin 129.

Horizontal Condensation Pump

Capacities, Horsepower and Floor Space tables may be had by asking for Bulletin.

Economy Pumping Machinery Co.

General Sales Offices

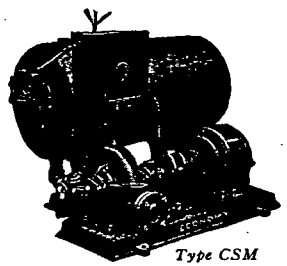
3431 West 48th Place, **Chicago, Ill.**

DISTRICT SALES OFFICES

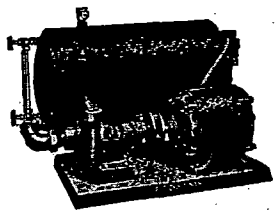
BALTIMORE, MD., 522 Park Avenue
BOSTON, MASS., 141 Milk Street
BUFFALO, N.Y., Erie County Bank Building
CHATTANOOGA, TENN., 401 Chattanooga Bank Bldg.
CINCINNATI, OHIO, 309 Main Street
DETROIT, MICH., 517 E. Larned Street
FORT WAYNE, IND., 2252 Columbia Street
INDIANAPOLIS, IND., 601 State Life Building
JACKSONVILLE, FLA., 660 College Street
KANSAS CITY, MO., 2020 Walnut Street
LOS ANGELES, CALIF., 215 W. Seventh Street
LOUISVILLE, KY., 305 Louisville Trust Building
MONTREAL P.Q., CANADA, 1072 Beaver Hall Hill
MIAMI, FLA., 113 N.E. Third Street
NEW ORLEANS, LA., 901 Carondelet Street
NEW YORK CITY, 39 Cortlandt Street
NEW YORK CENTRAL, 25 Wallace Ave., Scotia, N.Y.
OKLAHOMA CITY, OKLA., 710 N. Hudson Street
PHILADELPHIA, PA., Bourse Building
PITTSBURGH, PA., Fulton Building
PORTLAND, ORE., 201 Worcester Building
ROCHESTER, N.Y., 306 Laburnum Crescent
ST. LOUIS, MO., 321 So. Grand Boulevard
ST. PAUL, MINN., 308 Metropolitan Building
SAN FRANCISCO, CALIF., Monadnock Building

Economy Pumps

Economy Pumps and Receivers



Type CSM



Type CSS

Economy pumps and receivers are made in a variety of sizes and types for every pressure and capacity condition. The present line is the result of a long study and improvement by this Company which was one of the pioneers in the manufacture of Electric pumps and receivers.

The use of these pumps to improve circulation with a reduction in boiler pressure usually results in large fuel economies. The savings are particularly striking in the case of medium pressure plants where it is desired to work at low pressure during dull periods of the day.

The table below gives a partial list of sizes which are available in either solid shell or horizontally split case designs. Complete specifications and descriptions will be found in Bulletin No. 405.

All Economy pumps are substantially mounted on cast iron bases with machined pads. Either cast iron or steel receivers are used. The automatic control is assembled as a unit and is easily accessible for inspection at all times. The most important features of individual standard designs are given below.

Type CSS—A single suction solid shell unit with oil-less stand bearing and outboard ring oiling or radial ball bearing. The most popular of all Economy pumps and receivers; a thoroughly dependable unit at a moderate price.

Type CSM—A double suction horizontal split case unit with enclosed bronze impeller with ring oiling bearings. This unit has been designed for use where the service is unusually severe as where equipment of the highest grade is desired.

Type CST—Multi-Stage Pumps for pressures above 40 lb. They are bronze fitted with ring oiling bearing at the driving end and radial ball bearing at the outboard end.

No. of Unit	Capacity in Sq. Ft. Direct C. I. Radiation	Pump Capacity G.p.m.	Receiver Capacity Gals.	Motor Horsepower				
				10 lb.	15 lb.	25 lb.	60 lb.	100 lb.
6	2000	7½	13	¼	..	..	..	..
6½	3500	12	16	⅓	..	..	..	..
7	5000	15	20	½	¾	1½	3	5
7½	7500	20	26	½	¾	1½	3	5
8	10,000	25	33	½	1	1½	3	5
8½	15,000	37	41	¾	1	2	5	5
9	25,000	60	49	1	2	3	5	10
9½	35,000	80	57	1½	2	3	7½	10
10	50,000	110	82	2	2	5	7½	15

Economy Underground Pumps and Receivers Type CU



Type CU

Underground pumps and receivers are used where returns are so low that a pit would be required for a horizontal pump.

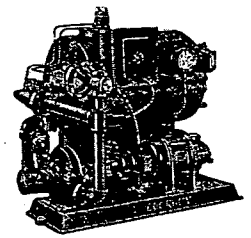
The underground unit consists of a special vertical bronze fitted pump having renewable bearings throughout and a cast iron receiver which is permanently resistant to corrosion and special type of float mechanism is used with swivel type stuffing box.

When necessary to use an underground pump on high pressure job the standard low pressure unit may be used discharging into the receiver of a high pressure horizontal pump. Our engineering department will be pleased to work out details of such installations. See Bulletin No. 405.

Type CU. Underground Pumps and Receivers

Capacity Sq. Ft.	H.P., 10 lb. Discharge Pressure	Motor Hp. 20 lb.	Pump Capacity G.p.m.	Receiver Capacity Inches	Disch. Size Inches	Capacity Sq. Ft.	H.P., 10 lb. Discharge Pressure	Motor Hp. 20 lb.	Pump Capacity G.p.m.	Receiver Capacity Inches	Disch. Size Inches
2000	¼	¾	7½	24 x 30	1	10,000	½	1½	25	24 x 36	1½
3500	⅓	¾	12	24 x 30	1	15,000	¾	1½	37	30 x 36	1½
5000	½	1	15	24 x 30	1¼	25,000	1	2	60	30 x 48	2
7500	½	1	20	24 x 36	1¼	50,000	3	5	110	36 x 48	2½

Improved Economy Centrifugal Return Line Vacuum Pump

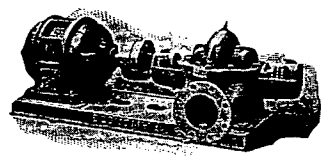


Type 2234

The improved Economy Vacuum heating pump is equipped with horizontal split case centrifugal pumps in sizes over 5000 ft. (smaller sizes are equipped with bronze fitted solid shell pumps). All parts of the pump are accessible without breaking pipe connections or dismantling the unit. The float control is located close to the floor so that a close water line may be maintained when operating as a gravity system. The boiler feed arrangement is positive and simple. The entire apparatus is shipped completely assembled and wired in accordance with the National Electric Code. In addition to the single pump duplex units are furnished which consist of single tank, two pumps and motors. Tests with calibrated orifices are made on all pumps before shipment. Standard pumps are designed for operation against 20 lb. pressure but reasonably prompt delivery can be made on units for discharge pressure up to 150 lb. See Bulletin No. 409.

Economy Centrifugal Vacuum Pump

Unit No.	Capacity in Sq. Ft. Direct C. I. Radiation	Motor Horse Power	Cubic Feet Air per Min.	Size Discharge to Boiler	Size Return Inlet	Shipping Weight
CV-1	2,500	¾	1¾	¾	1½	650
CV-2	5,000	1	4	1	2	750
CV-3	8,000	1½	6	1	2½	900
CV-4	16,000	2	10	1¼	3	1,025
CV-5	20,000	3	15	1¼	3	1,150
CV-6	27,500	5	19	1½	3½	1,300
CV-7	40,000	5	24	1½	4	1,550
CV-8	65,000	7½	40	2	5	1,800
CV-9	100,000	10	60	2½	6	3,100
CV-10	150,000	15	90	2½	6	4,000



Type M

Economy Multi-Stage Pumps

Made in the horizontal split type in sizes 2½ and larger, smaller sizes are vertically split. In these pumps the head per stage has been limited to a figure at which high efficiency and long life is obtained. Distinctive features of Economy horizontally split design are solid one piece bronze diaphragms, the volute in every stage and the hydraulic balancing device. The table shows maximum head at 1750 r.p.m. Higher pressures are obtained with 3600 revolution units. Specifications are given in Bulletin No. 406.

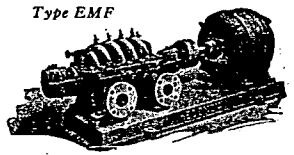
Multi-Stage Pumps for High Pressure House Supply Boiler Feeding, Etc.

Capacity, gals. per min.....	25	50	100	160	250	350
Pump number.....	1	1½	2½	2½	3	3
Horsepower per 100 ft. head..	2.5	3.75	5.5	7.0	11.0	17.0
Max. head at 1750 r.p.m.....	300	400	600	750	750	550

Economy Double Suction Centrifugal Pump

Economy general service single stage centrifugals are made in a complete range of capacities up to 3500 G.P.M. They are widely used for general water supply, hot water circulation, brine circulation, air washing service, etc. They embody the newest hydraulic developments which give them an unusually high efficiency over a broad range. The mechanical design is simple and rugged. Description and complete table is given in Bulletin No. 408.

Type EMF



M. J. Finn Pump Mfg. Co.

Manufacturers of Water Supply Systems and Centrifugal Pumps

Pittsburgh, Pa.

Supply Houses in New York, Chicago, Minneapolis and San Francisco

Copyright 1925 by M. J. Finn Pump Mfg. Co.

PRODUCTS:

Finn Patented Condensation Pump and Receiver.
Finn Drinking Water Circulating and Booster Pumps.
Also manufacturers of Refrigeration, Brine and Booster Pumps.
Finn Patented No Tank Water Supply Systems.

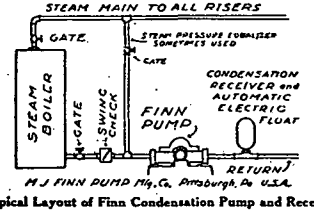


TRADE-MARK

Finn Fuel Saving Condensation Pump and Receiver

Returns condensation from radiators and return lines below the water line of boilers in all kinds of buildings, drying kilns, greenhouses, etc., also forces circulation in hot water heating systems.

Finn fuel saving condensation pump and receiver can be located on a level with or below the boiler. By means of automatic electric control (furnished with the pump), it will return condensation from and eliminate sluggishness in all radiators, coils and return lines that are on a level with or below the boiler, permitting them to be filled with live steam instead of cold condensation.



Typical Layout of Finn Condensation Pump and Receiver

In returning the condensation to the boiler intermittently, the Finn pump creates a vacuum in the system, permitting the water in the boiler to boil at a lower temperature and, consequently, reduces the fuel consumption. In addition to the fuel saving feature, a better circulation is produced in all return lines, consequently these lines become very hot and serve as additional radiation.

The pump is the same as that used in the Finn water supply system described on the following page. It consists of only a few parts, is made of high grade materials, and, because of its simplicity, is not expensive. Impeller touches water only. No metal rub; no wear. The cost of the electricity required is insignificant.

Capacities—No. 1 pump, 4000 sq. ft. of direct radiation; No. 2 pump, 7000 sq. ft. direct radiation.

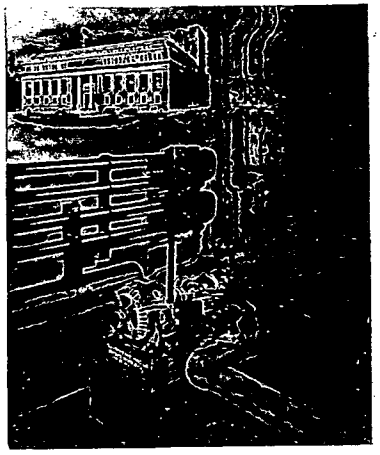
For larger operations, two or more pumps can be connected effecting great saving in electricity and fuel.

Specifications—The contractor shall furnish and install one No. ..... Finn Automatic Electric Condensation Pump and Receiver, with horizontal split case, all-bronze pump with Monel metal shaft, automatic control and ..... hp., ... cycle, ... phase, ... volt direct [alternating] current motor manufactured by M. J. FINN PUMP MFG. CO., Pittsburgh, Pa.

Finn Drinking Water Circulating and Booster Pumps

Used for circulating drinking water in all classes of buildings: hospitals, schools, institutions, hotels, restaurants, factories, and office buildings. These pumps are the same as those used in the Finn water supply system described in opposite column.

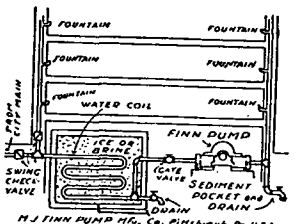
Entirely Closed Method—A sanitary and economical method by which drinking water is cooled in the pipe main which is coiled at any desirable location, the coil being contained in a wood



Finn Pump Supplying Crystal-clear Pure Water in Mellon National Bank, Pittsburgh

To choose wisely is to avoid trouble and worry FINN **Simplicity—Real Quality—Supremacy**

United States National Museum Smithsonian Institution Washington, D. C.	St. Rita's Home for Infants	Syria Mosque, A.A.O.N.M.S. Pittsburgh, Pa.
Hippodrome Theatre Boro of Manhattan New York City	U. S. Steel Corp. Mellon National Bank Pittsburgh, Penna.	Stoneboro Wesleyan Methodist Camp Meeting Association
	Sheridan Square Theatre	Pennsylvania, R. R.



Closed Method of Drinking Water Circulation

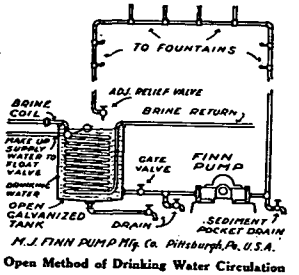
or steel box usually insulated with cork lining (standard size of cork slabs on the market is 12 in. wide, 36 in. long, and 3 in. thick). Box can be placed either below, above or level with basement or any floor regardless of location of pump, and the box should have a drain as shown in the sketch.

Ice can be packed around the coil in the box, or, if a refrigerating machine is used, the brine pipe of the latter can be run to and coiled inside the box, there being room for both the brine coil and the coil containing the drinking water. Check valves shown in sketch keep the cold water from backing up into the street or building main and also send make-up water direct to the coils and pump.

The closed method, using either a No. 1 or No. 2 Finn Pump, will provide abundant circulation and take care of maximum demands during rush periods in the largest buildings.

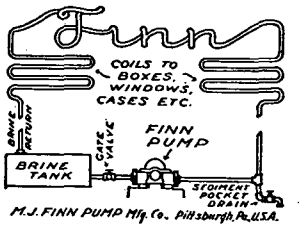
Specifications for Closed Method—The contractor shall furnish and install one No. 1 Finn Noiseless pure drinking water bronze and Monel metal pump with ¼ hp., ... cycle, ... phase, ...volt, direct [alternating] current motor and two brass swing check valves manufactured by M. J. FINN PUMP MFG. CO., Pittsburgh, Pa., or,

The contractor shall furnish and install one No. 2 Finn Noiseless Pure Drinking Water bronze and Monel metal pump with ½ hp., ... cycle, ... phase, ... volt, direct [alternating] current motor and two brass swing check valves manufactured by M. J. FINN PUMP MFG. CO., Pittsburgh, Pa.



Open Method of Drinking Water Circulation

Open Method—By this method, drinking water contained in an open galvanized tank is cooled by brine coils submerged in the water. The Finn pump should be located in the drinking water main on the



Method of Brine Circulation

house side of the cooling tank. A wheel handle relief valve can be easily set by the user to suit any kind or size of building. The relief valve partly closes when faucets or fountains are open; when the latter are closed, the relief valve opens a little more permitting water to return to the tank, thereby maintaining constant circulation.

The open system requires one No. 2 Finn pump, or for large operations; two No. 2 pumps to take care of great demands in rush periods.

Specifications for Open Methods—The contractor shall furnish and install one No. 2 Finn Noiseless Pure Drinking Water bronze and Monel metal pump with ½ hp., ... cycle, ... phase, ... volt, direct [alternating] motor manufactured by M. J. FINN PUMP MFG. CO., of Pittsburgh, Pa.

Brine Circulation Pump—The contractor shall furnish and install one No. 2 Finn Calcium or Sodium Brine Pump with ½ hp., ... cycle, ... phase, ... volt direct [alternating] current motor manufactured by M. J. FINN PUMP MFG. CO., Pittsburgh, Pa.

Finn Patented No Tank Pure Water Supply Systems

The Finn patented centrifugal pump or water system *requires no tank* and delivers large quantities of water, under high pressure, direct from its source to the faucets in a steady, even flow (without pulsation). It has few parts and runs smoothly and quietly.

The pump has bronze body, Monel metal shaft, heavy cast iron base and high grade motor. Pump impeller touches water only. No metal rub; no wear.

The Finn pump does away with gears, pulleys, buckets, belts, pump valves, wire springs and rusty water tanks.

Dimensions—Floor space: No. 1 pump, 16 x 26 in.; No. 2 pump, 16 x 30 in. Approximate weight, 195 lb. Either opening serves as inlet or outlet. Tappings suitable for all buildings. Can be connected into any service line regardless of size.

Specifications—One No. 1 Finn Patented Pure Water (No Tank) System with ½ hp., ... cycle, ... phase, ... volt, direct [alternating] current motor manufactured by M. J. FINN PUMP MFG. CO., Pittsburgh, Pa.

Prompt Shipments

We maintain a large and complete stock of all pumping units described herein in all principal cities so that prompt deliveries can be made. Plumbers, steamfitters, sprinkler men and others understand our products and can install them without any special directions. The installation, being very simple, requires only ordinary care.

Homeopathic Hospital Presbyterian Hospital Gilmore Drug Bldg. Pittsburgh Box Factories Dr. Zimmerman Dairy Youngstown, Ohio	Mercy Hospital St. Johns Hospital Smith Greenhouses Greenburg, Pa. Saunders Estate West Palm Beach, Florida	Lutz & Schramm Plant Home Dairy Bldgs. Pontiac, Mich. Seibold Estate Bobcaygeon, Canada

Hotels, Restaurants, Factories, Schools, Farms and Residences too Numerous to Mention.

The Nash Engineering Company

Plant and General Offices

South Norwalk, Conn., U. S. A.

Sales Offices

Atlanta	618 Atlanta Trust Co. Bldg.	Miami	113 N. E. Third St.
Birmingham	2224 Comer Bldg.	Minneapolis	808 La Salle Ave.
Boston	Nottingham Bldg., Copley Sq.	Montreal	417 New Birks Bldg.
Buffalo	317 Chamber of Commerce	New Orleans	344 Camp St.
Butte, Montana	910 Arizona St.	New York, N. Y.	Graybar Bldg.
Chattanooga	1104 James Bldg.	Omaha	Baum Bldg.
Charlotte	608 Builders Bldg.	Philadelphia	254 South 15th St.
Chicago	925 Monadnock Block	Pittsburgh	1430 Oliver Bldg.
Cleveland	1600 Union Trust Bldg.	Portland, Ore.	224 Pine St.
Dallas	1020 Mercantile Bank Bldg.	Richmond	301 American National Bank Bldg.
Denver	1226 California St.	St. Louis	4200 Forest Park Blvd.
Detroit	Kerr Bldg.	Salt Lake City, Utah	Dooly Bldg.
Indianapolis	821 Hume-Mansur Bldg.	San Francisco	Sharon Bldg.
Kansas City, Mo.	208 Mutual Bldg.	Seattle	901 L. C. Smith Bldg.
Los Angeles	1224 S. San Pedro St.	Toronto	90 Chestnut St.
Louisville	901 Realty Bldg.	Vancouver	410 Homer St.
Memphis	1714 Exchange Bldg.	Washington, D. C.	Barr Bldg.

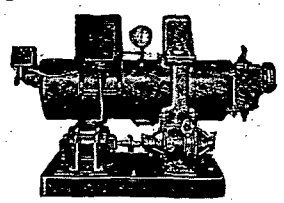
PRODUCTS

Return line and air line vacuum heating pumps. Condensation pumps. Standard and suction centrifugal pumps. Sewage ejectors. Sump pumps. Compressors and vacuum pumps for air and gases.

Return Line Vacuum Heating Pump

Removes air and condensation from the return line of vacuum steam heating systems, discharges the air to the atmosphere, and returns the water to the boiler.

The pump consists of two independent units combined in a single casing—an air unit and a water unit. Impellers of both units are mounted on the same shaft, supported on annular ball bearings outside the casing. The pump is bronze fitted throughout.



Jennings Return Line Vacuum Pump

The air unit exhausts air and vapors and delivers these to the atmosphere without back pressure. The water unit removes the condensation and pumps it directly into the boiler. By handling the air independently of the water, horsepower is saved, with a proportionate reduction in the cost of current.

Supplied either direct connected to standard electric motors, for belt drive, or for steam turbine drive. For continuous or automatic operation against pressures up to 40 lb.

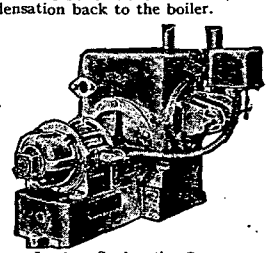
Capacities of Jennings Heating Pumps

Size	Equivalent Direct Radiation Sq. Ft.	Air Capacity Cu. Ft. per Min.	Water Capacity at 180°F. Against 10 lbs. Pressure Gal. per Min.	Actual H. P. for Delivering Water Against 10 lbs. Pressure.	R.P.M. & Motor H.P. 10 lbs. R.P.M.	10 lbs. H.P.	20 lbs. R.P.M.	20 lbs. H.P.
T	2,500	3	4	0.33	3600	⅛	3600	½
U	5,000	3	9	0.33	3600	⅛	3600	½
V	10,000	6	14	0.9			3600	1
B	16,000	9	22	1.4	1800	1½	1800	2
C	26,000	15	35	2.0	1800	2	1800	3
D	40,000	19	60	2.8	1800	3	1800	5
E	65,000	34	90	3.9	1800	5	1800	7½
F	100,000	50	140	7.0	1800	7½	1800	10
G	150,000	102	200	9.8	1200	10	1200	15

Condensation Pump and Receiver

Removes the condensation from radiators in return line steam heating systems, particularly radiators set below the boiler waterline level, and pumps the condensation back to the boiler.

By making the pump casing a part of the return tank, and bolting the motor base to the tank, floor space is conserved. The rectangular construction permits installation in a corner against the wall.



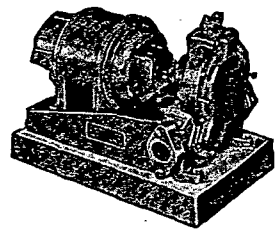
Jennings Condensation Pump

Capacities of Jennings Condensation Pumps

Size	Equivalent Direct Radiation Sq. Ft.	Water Capacity G.P.M.	Tank Capacity C.P.M.	R.P.M. 10 lb. Discharge Pressure	Motor H.P. 10 lb. Discharge Pressure
32	2000	4	6	3600	⅛
34	4000	6	6	3600	⅛
36	6000	8	6	3600	⅛
38	8000	11	12	3600	⅛
310	10,000	13	12	3600	⅛
312	12,000	16	12	3600	½
316	16,000	22	12	3600	½

Centrifugal Pump

For circulating hot and cold water; boosting city water pressure; handling water in air washing and conditioning; removing condensate from heating systems, blow-down from soot blowers and superheaters, exhaust drips from steam ejector air pumps and other auxiliaries; pumping refrigerator can and core water, evaporator feed, cooling tower and condenser water, screen wash water, oil engine jacket water, ash sluicing water.



Jennings Centrifugal Pump

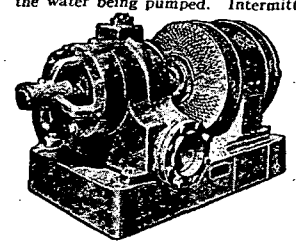
Compact—motor armature and pump impeller are mounted on the same shaft. Simplicity—no bearings in pump casing, only one stuffing box. Accessible—pump impeller can be removed without breaking pipe connections, touching packing, or disturbing shaft alignment.

Supplied in 1¼, 1½, 2, 3, 4 and 6 in. sizes for handling up to 1000 g.p.m. Heads up to 250 ft. Bronze fitted pump is standard construction. Also furnished in all-bronze or all-iron for special service.

Centrifugal Pump Operating With Suction Lift

When the Jennings Suction Centrifugal is started, the built-in Nash Hytor Vacuum Pump exhausts the air from the casing and suction piping. Water is quickly drawn into the pump. Full rated capacity is delivered without delay.

Successful performance is assured under conditions where water level is likely to fall, or where air or gas is handled together with the water being pumped. Intermittent operation is possible without the need for a foot valve.



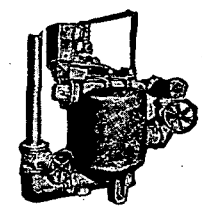
Jennings Suction (Self-Priming) Centrifugal Pump

Furnished in 2, 3, 4 and 6 in. sizes for capacities up to 1000 g. p. m. Heads up to 100 ft. Supplied either bronze fitted or all bronze construction.

Sewage Ejector

For pumping unscreened sewage or drainage from basements below the street sewer level, handling crude sewage from low level districts, pumping effluent, sludge and other heavy liquids.

The Jennings Sewage Ejector is of the pneumatic type. Air, compressed to the necessary working pressure by a Nash Hytor Compressor, is used as the motive power to pump the accumulated sewage from a pot to the sewer.



Jennings Sewage Ejector

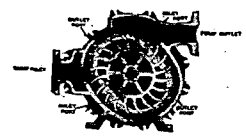
Air is compressed, delivered, and used *only when* required. There are no air storage tanks, reciprocating air compressors, or screens. Air valves are avoided.

Furnished in several standard sizes for handling up to 1500 gal. per min. Heads up to 50 ft.

Compressors and Vacuum Pumps for Air and Gases

The rotor, consisting of a cylindrical hub around the periphery of which are chambers or spaces formed by heavy shrouds cast integrally, revolves freely in an elliptical casing or housing filled with water.

As the rotor turns, it carries the water around with it. The water under the influence of centrifugal force, is compelled to follow the contour of the casing, and alternately to enter and to leave the rotor chambers, twice in each revolution.



Sectional View of the Nash Hytor Compressor or Vacuum Pump, Showing the Unique Principle of Hydro-Turbine Operation

As the water recedes from the rotor, air is drawn into the chambers through the inlet port. As the water is subsequently forced back into the rotor by the converging casing, the air is compressed and then discharged from the rotor through the outlet port.

A separator, supplied with each compressor, frees the delivered compressed air of entrained moisture.

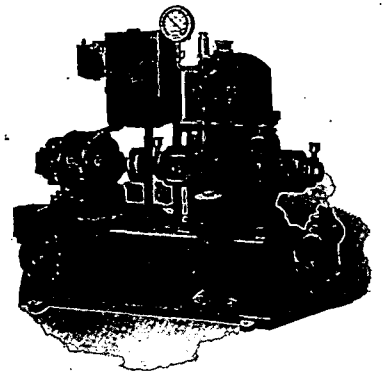
Supplied in several standard sizes for handling up to 5000 cu. ft. of free air per min. For discharge pressures up to 20 lbs.; vacuums up to 20 in. of mercury column. Cast iron standard construction. Bronze fitted pumps, and pumps of solid bronze and other alloys furnished special.

Bulletins

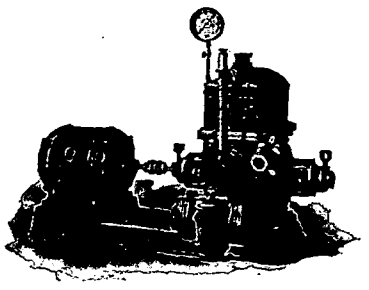
No. 10. Nash Hytor Compressors.
No. 11. Nash Hytor Vacuum Pumps.
No. 15. Jennings Return Line Vacuum Heating Pumps, piped-up type.
No. 17. Jennings Air Line Vacuum Heating Pumps.
No. 52. Jennings Standard Centrifugal Pumps.
No. 63. Jennings Condensation Pumps.
No. 67. Jennings Sewage Ejectors.
No. 71. Jennings Return Line Vacuum Heating Pumps, manifold type.

Skidmore Corporation

General Offices and Factory: 1535 Dayton Street, **Chicago, U.S.A.**



Interceptor Tank Base Type
Furnished when vacuum and float control is desired



Standard Type
Furnished for continuous service or when vacuum control only is desired

The pump in its construction, materials used and operation remains the same as shown for our standard type.

The object of the design is to have a unit compact in arrangement, combining the vacuum pump with an interceptor tank, thereby saving floor space, and securing a low water line in the system when operating on float control.

In the arrangement shown a hollow base has been used on which the pump, motor and electrical equipment are mounted. A float operated switch is installed in the base to control the pump from water level in same. All wiring between the starter, vacuum switch and float switch will be installed at the factory.

With this construction the unit arrives complete, ready to set in place, and by simply connecting the return and discharge pipes to flanged openings and wiring to starter the pump is ready to run.

The use of a cast iron tank as a base eliminates the necessity of a concrete base for mounting.

We feel sure that the low operating water line secured in this design will appeal to Architects and Engineers as it will in many installations eliminate the placing of the pump in a pit to secure drainage of low radiation and returns.

The operating point on these units will be from 10 in. on the smaller sizes to 12 in. on the larger, from floor level.

Where a self-contained unit reliable and quiet in operation is desired the Skidmore will be found.

Positive removal of air and water from the heating system and the return of water to the boiler.

A unit of pleasing design of large capacity and maintained efficiency, occupying less than half the floor space of pumps for similar service, self-contained all on one base with return connections close to floor with strainer arranged so that connections can be made to one or both sides as desired. Furnished with direct connected motors for 10 and 20 lb. pressure, or up to 60 lb. if desired. For continuous service or with automatic control.

A strictly high grade product, bronze rotors and bronze fitted throughout, shaft carried on oversize ball bearings, no close clearances or rubbing parts.

CAPACITIES FOR 10-in. VACUUM—10 and 20 lb. Pressure

Size of Pump	Capacity Sq. Ft. of Radiation	Gallons of Water per Minute	Motor Horsepower		Size of Companion Flanges for Returns	Size of Discharge to Boiler	R.p.m.
			10 lb.	20 lb.			
0	5000	8	¾	1	1½"	1"	1800
1	8000	11	1	1½	2"	1⅛"	1800
2	16,000	22	1½	2	2"	1¼"	1800
3	26,000	35	2	3	3"	1½"	1800
4	40,000	60	3	5	3"	2"	1800
5	65,000	90	5	7½	4"	2"	1800
6	100,000	150	7½	10	5"	2½"	1800

The Trane Company

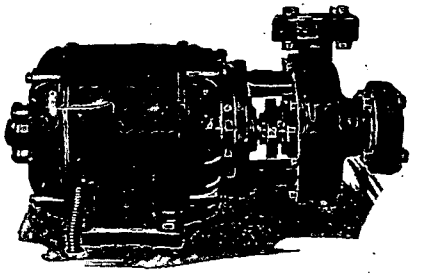
La Crosse, Wis.

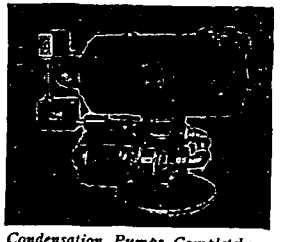
See Heat Cabinets and Concealed Heaters, pages, 622, 623; Unit Heaters, page 638
Heating Specialties, pages, 786, 787

BRANCHES IN PRINCIPAL CITIES

TRANE PUMPS

The new line of Trane Centrifugal Pumps develop higher efficiencies and consequently require smaller motors *than average centrifugal pumps.* On the smaller pumps three-quarter horsepower motors do work that has required one or one and one-half in the past. On the larger pumps, seven and one-half horsepower motors do work that has always required ten. On condensation units up to 30,000 sq. ft., the pump is direct connected to the motor by a special motor end plate. Outfits for condensation work are furnished completely hooked up. That is, the motor and pump, tank, switch box and motor protective equipment are mounted on one base and completely wired ready to install.





Condensation Pumps Completely Wired Ready to Install

These pumps can be furnished with impellers suitable for brine or other work requiring special construction.

The Trane Line of Pumps includes condensation pumps, sump pumps, circulating pumps and booster pumps. Complete information and *bulletins will be sent on request.*

CAPACITIES OF TRANE CONDENSATION PUMPS

Pump No.	Radiation in Sq. Ft.	Min. Gal. per Min.	Max. Pres. at Pump	Motor H.P.	Unit Complete See Notes Approximate Ship. Wt., Lb.	Pump No.	Radiation in Sq. Ft.	Min. Gal. per Min.	Max. Pres. at Pump	Motor H.P.	Unit Complete See Notes Approximate Ship. Wt., Lb.
410	4000	6-8	10	¼	250	1510	15000	25-30	10	½	525
415	4000	6-8	15	½	275	1515	15000	25-30	15	¾	550
420	4000	6-8	20	½	275	1520	15000	25-30	20	¾	550
430	4000	6-8	30	½	275	1530	15000	25-30	30	1	575
440	4000	6-8	40	¾	300	1540	15000	25-30	40	2	625
						1550	15000	25-30	50	3	650
610	6000	9-12	10	¼	400	2010	20000	30-40	10	¾	550
615	6000	9-12	15	½	425	2015	20000	30-40	15	1	575
620	6000	9-12	20	½	425	2020	20000	30-40	20	1	575
630	6000	9-12	30	½	450	2030	20000	30-40	30	2	625
640	6000	9-12	40	¾	450	2040	20000	30-40	40	2	625
						2050	20000	30-40	50	3	650
810	8000	12-16	10	¼	400	2510	25000	40-50	10	1	575
815	8000	12-16	15	½	425	2515	25000	40-50	15	1	575
820	8000	12-16	20	½	425	2520	25000	40-50	20	1½	600
830	8000	12-16	30	½	450	2530	25000	40-50	30	2	625
840	8000	12-16	40	¾	450	2540	25000	40-50	40	3	650
						2550	25000	40-50	50	3	675
1010	10000	15-20	10	¼	425	3010	30000	50-60	10	1	575
1015	10000	15-20	15	½	450	3015	30000	50-60	15	1	575
1020	10000	15-20	20	½	450	3020	30000	50-60	20	1½	625
1030	10000	15-20	30	½	475	3030	30000	50-60	30	2	625
1040	10000	15-20	40	¾	475	3040	30000	50-60	40	3	675
						3050	30000	50-60	50	3	700

Data on larger sizes will be furnished upon request.

Westco-Chippewa Pump Company

(Incorporated)

Factory and General Offices: **Davenport, Iowa**

Branches

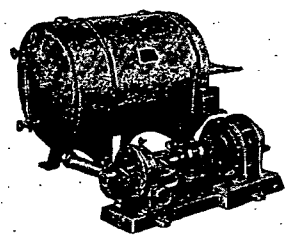
WESTCO-CHIPPEWA PUMP CO.
1415 Howard Street
CHICAGO

NEW YORK OFFICE
90 West Street
NEW YORK CITY

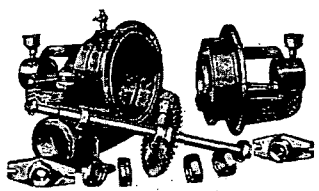
WESTCO-CHIPPEWA PUMP SALES CO.
579 Howard Street
SAN FRANCISCO, CALIF.

WESTCO PUMPS

Westco Condensation Pumps and Receivers



Single Stage—Double Suction



Only One Moving Part

WESTCO Pumps and Receivers are used for automatically returning to low and high pressure steam plants, condensation from radiation systems, heaters, steam coils, etc. They save the water supply, and to a considerable extent the fuel by returning the condensate while hot, also inducing proper circulation in the system.

Each unit consists of WESTCO pump direct connected to motor and heavy steel plate galvanized receiver tank mounted on heavy cast iron pedestals which form a solid foundation. Entirely automatic operation. Water gauge and necessary fittings between pump and receiver tank are furnished with all units.

The WESTCO is a double suction ball bearing pump, possessing perfect hydraulic balance, which insures long life and freedom from adjustments and repairs. The design allows complete disassembly without disturbing the suction and discharge connections.

Because of its wide operating range the WESTCO eliminates the necessity for carefully computing the head against which it must operate. WESTCO pumps will operate against variations of as much as 50 per cent either way in the head against which they were intended to operate. Even though the safety valve is set higher than it should be, this remarkable pump still returns the condensate to the boiler.

In addition to the features outlined, the WESTCO is silent, smooth running, requires very little space, because of its extreme compactness and will operate for months with a minimum of attention.

SELECTION TABLE WESTCO CONDENSATION PUMP AND RECEIVER UNITS

Max. Sq. Ft. Direct Radiation	*Pump Capacity G.P.M.	†POUNDS PRESSURE—Against which Pump will discharge, operating at 1750 r.p.m.						
		10	20	30	40	50	60	100
1000 to 2000	5	C3H6-¼	C4H6-¼	C4H6-¼	C5L7-¾	C5L7-¾	C5K8-1	C6K7-3
2000 to 4000	10	C4G7-¼	C4G6-½	C4G6-¾	C5K8-1	C5K8-1	C6K7-1½	C6K7-3
4000 to 6000	15	C4G6-½	C4G6-½	C6K7-1	C6K7-1	C6H7-2	C6H7-2	C6H6-5
6000 to 7500	20	C4F6-¾	C4F5-¾	C6H7-1½	C6H7-1½	C6H7-2	C6H6-3	C6H5-5
7500 to 10000	25	C4F5-½	C4D7-1	C5F8-1½	C6H6-2	C6H6-3	C6H6-3	C6H5-5
10000 to 15000	30	C4F5-½	C4D7-1½	C5F6-2	C6H6-2	C6H5-3	C6H5-5	C7H8-7½
15000 to 20000	40	C4D6-¾	C4D5-1½	C5F6-2	C6H5-3	C6F8-5	C6F8-5	C7H8-7½
20000 to 25000	50	C4D5-1	C5F5-2	C5D7-3	C6F8-3	C6F7-5	C6F6-5	C7H7-10
25000 to 30000	60	C5F5-1½	C5D7-3	C6F7-3	C6F7-5	C6F6-5	C7H7-7½	C7H7-10
30000 to 35000	70	C5D7-1½	C5D7-3	C5D6-5	C6F6-5	C6F6-5	C7H7-7½	C7H7-10
35000 to 40000	80	C5D7-1½	C5D7-3	C5D6-5	C6F5-7½	C6F5-7½	C7H7-7½	C7H6-15
40000 to 45000	90	C5D7-1½	C5D6-5	C5D6-5	C6F5-7½	C6F5-7½	C7H6-10	C7H6S-20
45000 to 50000	100	C5D6-2	C5D6-5	C6F5-5	C7H6-7½	C7H6-10	C7H6-10	C7H6S-20

*Pump capacity based on handling 190 deg. fahr. water.

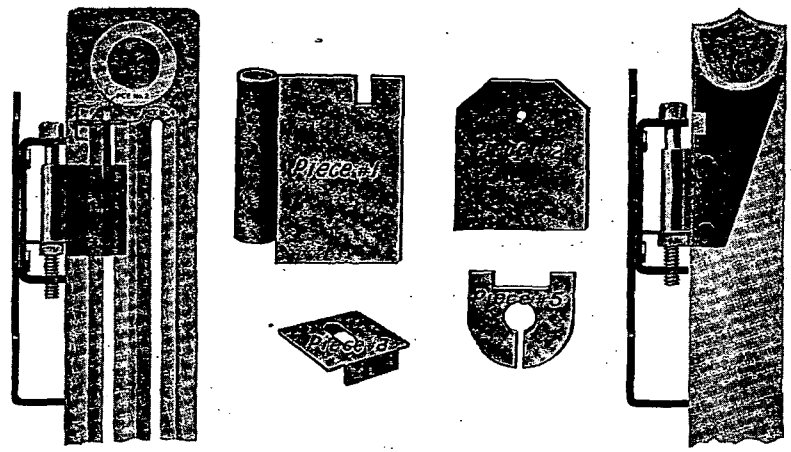
†Information on pumps for pressures not shown on table furnished on request.

NOTE.—The above unit numbers indicate the model WESTCO pump and size motor. Example: Unit number C3H6¼ indicates a model 3H6 WESTCO Double Suction Bronze fitted pump requiring a ¼ hp. 1725 r.p.m. motor. See Dimension table for size of receiver.

Clip-Bar Manufacturing Co.

RADIATOR BRACKETS

1119 to 1125 Roy Street, **Philadelphia, Pa.**



SIMPLEX BRACKET
Carrying Tube Radiator

SIMPLEX BRACKET
Carrying Wall Radiator

The "Simplex" Top Hung Radiator Bracket, for tube radiation, is designed upon an entirely new principle. Heretofore radiator brackets have carried the radiators from the central hub of the radiator, either top or bottom, but the "Simplex" bracket carries the radiator from the rear tubes which eliminates the necessity of using a great variety of supporting hooks or shoes, several length of wall plates and a number of sizes of tie rods.

Construction: Rigid wrought steel construction throughout, unbreakable, guaranteed.

Tube Radiators: The Simplex Radiator Bracket is made *in one size only, which* accommodates all standard tube radiators regardless of make, number of tubes or height.

Wall Radiators: The hooks for wall radiators are interchangeable with hooks for tube radiators and accommodate all standard makes of wall radiation.

Top Hung: No projection beyond face or below bottom of radiator. **Always clears surbase.**

Concealed: Brackets are in back of the radiator and below the top of same.

Brackets are concealed yet accessible for making adjustments.

Clearance from Wall: Simplex Top Hung *Radiator Bracket hold* the radiator two inches from the wall.

Installation: Easily and quickly attached to wall, one ½ in. bolt is all that is necessary. Two can be used if desired. Radiators can be removed from brackets for painting without disturbing the adjustment or any part of the bracket.

A locking device is provided on the bracket to hold hook at right angle to wall to receive radiator.

Adjustment: Brackets are adjustable both vertically and horizontally. The 2½ in. slot in the wall plate eliminates the *necessity of exact* measurement in locating bolts. Radiators can be adjusted after placing on hanger.

Economy: One size brackets for all sizes of standard tube radiators, with interchangeable hooks for wall radiation.

Eliminates the use of various height brackets and various sizes of hooks and tie rods. The elimination of the tie rods is an important advantage as the tie rods are not only unsightly but take time to install. No left overs from one job that cannot be used on the next.

No expensive delays waiting for brackets due to a change in size or height of radiators during progress of the *work. A complete assembled unit.*

By carrying stock on hand, work can be immediately installed without waiting for additional parts.

Safety: When the radiator is in place on the hook of the "Simplex" bracket it is securely held by the slot in the hook and cannot be dislodged without lifting off the hook.

Weight: Both wall and tube brackets weigh about 4½ lbs. each.

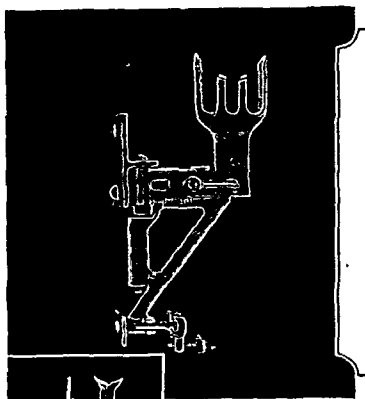
The Little Giant Manufacturing Company

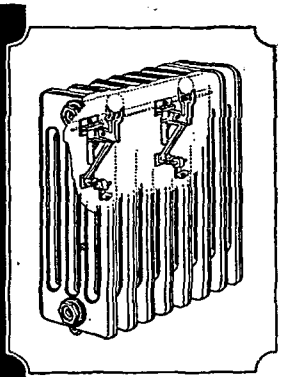
Minneapolis, Minnesota

Manufacturers of

Tu-bu-lur Radiator Brackets **Little Giant Concrete Inserts**
Little Giant Radiator Hangers **Little Giant Radiator Trucks**

Products distributed by United States Radiator Corp.—Sold by all leading jobbers





A New Principle

The New TU-BU-LUR *Radiator Bracket offers simplicity, economy, accuracy, elasticity, rigidity and strength. All adjustments needed for correct installation can be made in the bracket, itself.*

TU-BU-LUR RADIATOR BRACKETS

Modern radiators are of the tube type—modern radiation in all types of buildings is being wall-hung. The new TU-BU-LUR Radiator Bracket, revolutionary in its principles, comes as an answer to the demand for simplified radiator support.

The TU-BU-LUR is truly a universal bracket. In one style and but three sizes, it fits all tube type radiators, whether rod, slip nipple or screw nipple, regardless of make, width or pattern. To appreciate the value of this adaptability one has but to glance at the variations in tube radiator dimensions—for example a few leading makes of 6 tube radiators measure in width as follows:

Continental	9 in.
American	9⅛ in.
United States	10⅜ in.
Kewanee	10⅛ in.
Gurney	10⅜ in.

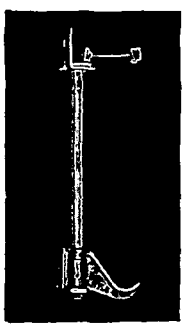
The TU-BU-LUR eliminates the need of close measurement and the selecting of a number of hanger pieces from a wide range of styles and sizes—the TU-BU-LUR fits all radiators.

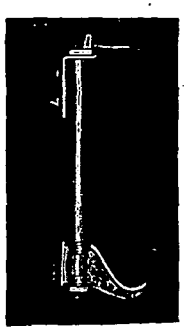
The TU-BU-LUR permits complete adjustments in any direction, level or plane. It provides for adjustment in and out from wall; for vertical alignment; for adjustment laterally in either direction; for raising or lowering radiator; for setting radiator in exact plumb. The TU-BU-LUR requires but one anchor bolt in the wall and requires no tie bolt.

Made of certified malleable iron, painted navy gray, the TU-BU-LUR is sold completely assembled, ready to install.

Little Giant Radiator Hangers

Little Giant Radiator Hangers are used for supporting all types of radiators that are to be bottom hung. The Little Giant is a one-bolt hanger, having both vertical and lateral adjustment and providing for expansion and contraction.





Style "L"—(Left) holds radiator 1⅛ in. from wall.
Style "P"—(Right) holds radiator 1½ in. from wall.

Healy-Ruff Company

Manufacturers of E-Z Radiator Hangers and Concrete Inserts

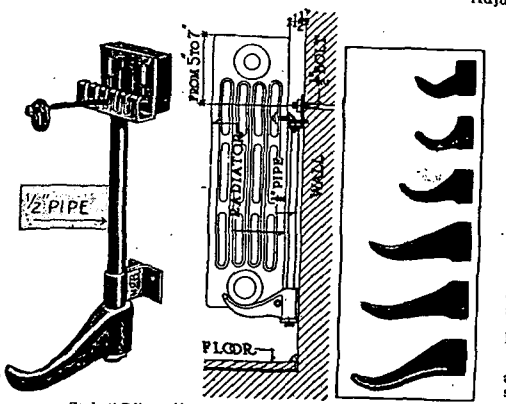
791 Hampden Avenue **St. Paul, Minn.**

Products

E-Z ONE-BOLT RADIATOR HANGER or BRACKET, for hanging all makes of wall and tube radiation.
E-Z CONCRETE INSERTS, for all pipe hangers.

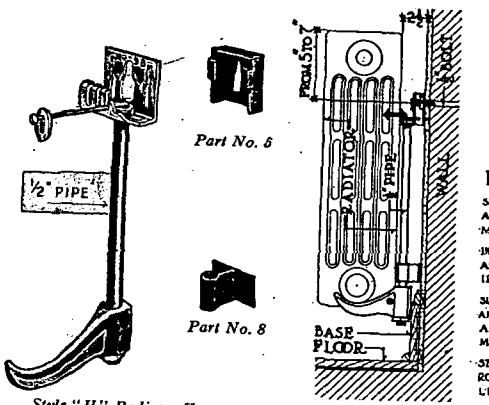
E-Z Radiator Hangers

Style "R," places radiator 1½ in. from wall, but is not adjustable for baseboard.
Style "H" places radiator 2½ in. from wall and provides for baseboard adjustment.
All style "R" hangers convertible, with parts No. 5 *and No. 8, into style "H."*
Both styles are made for wall, column and tube radiation.
All parts made of pressed steel except bottom hook support.



Style "R" Radiator Hanger, without baseboard adjustment

E-Z Radiator Hangers



Part No. 5

Part No. 8

Style "H" Radiator Hanger, with baseboard adjustment

All column and tube radiation is held in at the top with an invisible washer.

Advantages—

Easy to clean under the radiator.
Floors and carpets can be laid without disturbing radiator or connections. Nothing in way of mop or sweeper.
No carrying of radiators over new floors.
Anchor bolts can be placed in walls during construction. No accurate measurements required since hangers have both horizontal and *vertical adjustments.* (Vertical adjustments made with ¼-in. pipe.)
Only one bolt in the wall for each hanger.
Expansion can not affect anchor bolts in wall.
Entire hanger *invisible when installed.*
Adjustable for any height of baseboard.
Saves time and labor.
Radiators can be hung and permanent connections made before floors are laid.
Applicable to walls of wood, brick, tile or walls of any other material.
Desirable where vacuum cleaners are used.
Desirable where temperature control is used.

Typical Specifications—

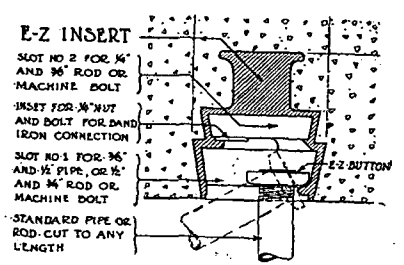
Where Baseboards Are Used—All radiation, unless otherwise noted, shall be supported on wall by means of E-Z Radiator Hangers, Style "H," or equal, and approved in writing by the architect; arranged to support the radiator 2½ in. from the wall and with baseboard adjustment.

Where Baseboard Adjustment Is Not Desired—All radiation, unless otherwise noted, shall be supported on wall by means of E-Z Radiator Hangers, Style "R," or equal, and approved in writing by the architect; arranged to support the radiator 1½ in. from the wall.

E-Z Concrete Inserts (7 in 1)

An insert with special features making it adaptable to all sizes of pipe hangers, whether supported by pipe, bolt, rod, or band iron.

Advantages—Made in just one size, and this one size accommodates ¼, ⅜, ½-in. pipe, ¼, ⅜, ½ and ¾-in. rod or bolt.
Ball and socket connection between insert and hanger.
Fully adjustable—allows play to compensate for expansion and inaccurate alignment of inserts. E-Z Button turns in the insert—no couplings or turnbuckles needed.
"Make Pipe Hanging Easy."



E-Z Concrete Insert

Copper Radiator Sales Corp.

Exclusive Distributors of Sage Radiation

Schenectady, N. Y. **Chicago,** Builders Bldg.

Warehouse Stocks: NEW HAVEN, CONN.—SCHENECTADY, N. Y.—CHICAGO, ILL.

Manufactured at New Haven and Bristol, Conn.

A real contribution to the science of heating is the Sage Tube-and-Fin Radiator and Cabinet for Steam, Hot Water or Vapor Systems.

It offers a new method of heating because of the correct application of the proven principles of heat transmission.

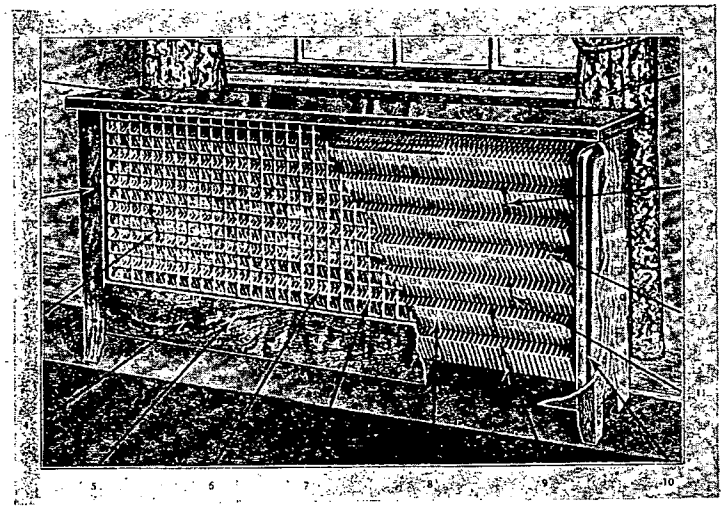
Sage Cabinet or Concealed Radiation is made of copper and brass, weighs about a pound per square foot of rated capacity and, because of the unique tube and fin arrangement, discharges heated air into the room at a level which is most conducive to comfort.

The Sage Radiator creates air movements, which are essential to comfort as well as beneficial to the heating efficiency of the radiator itself. The smooth straight air passages give the air an initial velocity which carries the heat rapidly into the room and prevents the collection of dust within the radiator.

As the Sage Radiator is very light in weight and consequently has only a comparatively small mass of metal to be heated, the running condition is reached in a minimum of time and heat is discharged before a cast-iron radiator gets warm to the touch.

Cabinets are furnished in natural wood grain finishes of red or brown mahogany, American brown walnut, French Ivory and pure white, also with prime coat only if so desired.

The Sage Radiator has Demonstrated its Worth During 5 Years of Operation



1. Double top. Cabinet is strong and durable. Width of top 10 in. May be used as window seat. Space for water pan.

2. Cabinets 20 in. high. Top is hinged. May be opened at 30 deg. during extremely cold weather increasing efficiency. Held rigidly in place.

3. Velocity of discharge carries heated air through the grille—an important feature, improving efficiency.

4. Finished in beautiful wood grain. Or in special finishes to harmonize with decorative schemes.

5. Lacquer finishes, very durable, highly polished and not damaged by heat or water.

6. Straight, or smooth air passages and the velocity of air movement keep the radiator clean.

7. Grille is press formed. Has 72 per cent free air opening.

8. Has double the heating surface of other radiators of same capacity. Heating surface is very effective, is all used and of equal value.

9. Design creates essential air movements. Cold air enters from beneath, or through the back, passing through the entire radiator and out from the room side. The flue or stack-effect is built in the radiator.

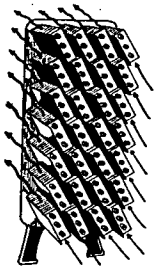
10. Radiator is made entirely of copper and brass. Tubes are seamless copper, fins light copper, headers stamped brass. Average weight a pound per rated square foot.

11. Fin channels split the heated air into many narrow streams. This causes rapid, natural circulation and remarkable uniform room temperatures.

12. Heats almost immediately. Throws off nine-tenths of the heat held in storage by other radiators. Never becomes "air bound." Is always noiseless.

13. Heats from the room side only—discharge is into the room at an angle of 60 deg. All heat is effective, "convected" heat—all effectively used. No "radiant" heat.

14. Draperies or decorations cannot become dirt-streaked or smudged. There are no vertical air movements between the Sage radiator and the wall and no heat.

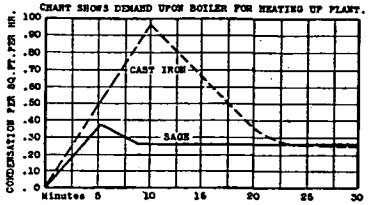


As shown by the accompanying diagram the Sage Radiator is of unit construction. The tubes are seamless copper, ⅜ in. outside diameter, .018 in. wall thickness and run horizontally. The fins are brass, .010 in. thick, 2¾ in. long and ⅞ in. wide. After the fins are assembled on the tubes the whole element is dipped in a tin bath to insure metallic contact between tube and fins.

The tubes are welded into the stamped tube sheets and the stamped headers or end tanks are also welded to the tube sheets, so forming an absolute tight unit.

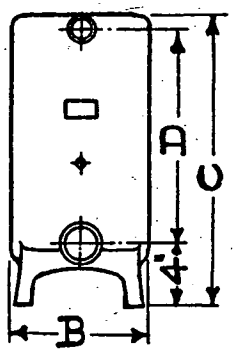
All Sage Radiators have upper and lower tappings of standard size.

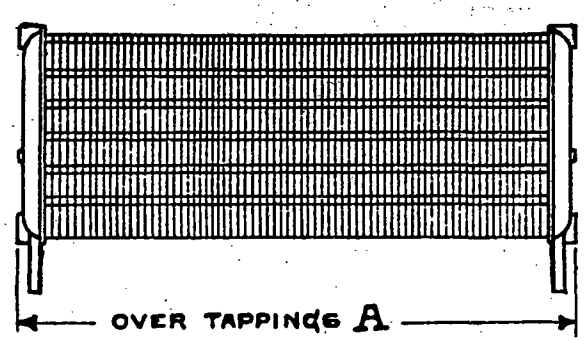
This diagram indicates that steam reaches all parts of the radiator quickly and practically no heat is held "in storage." The chart demonstrates also the advantage gained by the use of Sage Radiators on account of their small demands on the boiler during the heating-up period.



DIMENSIONS IN INCHES

Type No.	Approx. Sq. Ft. Rating	Tappings		Radiators				Cabinets* Height 20		B.t.u. Delivered per Hour	Water Contents (Pounds)	Actual Heating Surface (Sq. Ft.)	Weight (Pounds)	
		Upper	Lower	A Length	B Width	C Height	D	Length	Width				Radiator	Cabinet
22-10	10	¾	1	13	4⅛	16½	11⅜	13¼	5¼	2510	3.65	17.12	19	13
22-15	15	¾	1	18	4⅛	16½	11⅜	18¼	5¼	3615	3.97	24.67	22	16
22-20	20	¾	1	23	4⅛	16½	11⅜	23¼	5¼	4600	5.26	32.4	26	18
20-16	25	1	1½	19	8⅜	18	13⅜	19¼	9	5790	7.82	51.83	26	21
20-19	30	1	1½	22	8⅜	18	13⅜	22¼	9	7076	8.21	60.83	29	23
20-24	40	1	1½	27	8⅜	18	13⅜	27¼	9	9100	8.86	75.83	33	25
20-29	50	1	1½	32	8⅜	18	13⅜	32¼	9	11220	9.51	90.83	38	27
25-29	60	1	1½	32	8⅜	18	13⅜	32¼	9	13450	11.97	114.28	44	30
25-34	70	1	1½	37	8⅜	18	13⅜	37¼	9	15900	12.78	133.78	49	35
25-2-195	80	1	1½	42¾	8⅜	18	13⅜	43¼	9	18200	17.18	154.5	60	41
25-2-225	90	1	1½	48¾	8⅜	18	13⅜	49¼	9	20350	18.14	177.5	67	46
25-2-245	100	1	1½	52¾	8⅜	18	13⅜	53¼	9	22450	18.80	192.5	71	51
25-2-27	110	1	1½	57¾	8⅜	18	13⅜	58¼	9	24590	19.55	212.5	76	56
25-2-295	120	1	1½	62¾	8⅜	18	13⅜	63¼	9	26740	20.40	230.5	82	61
25-2-345	130	1	1½	72¾	8⅜	18	13⅜	73¼	9	28900	22.10	268.5	92	70





ROME BRASS RADIATOR
CORPORATION

1 East 42nd Street, New York

BOSTON CHICAGO CLEVELAND PHILADELPHIA PITTSBURGH

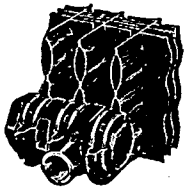
Representatives in Principal Cities

Robras 20–20 finned type radiators are scientifically designed non-corrosive extended surface radiators, especially developed to utilize the advanced principles of heating, wherein the heat-surface is enclosed, either within the building wall or a casing.

Robras Radiators utilize the enclosure as a stack within which they induce a positive movement of the heated air, expelling it *horizontally*, with sufficient velocity to insure a uniformity of heating thruout the adjacent space never before achieved without fans. Thus the ROME BRASS RADIATOR CORPORATION endorses this modern Method of Heating as incomparably superior to former practice, affording uniform comfort, economy, effective control, freedom from enormous weight and bulk, and freedom from intrusion upon the decorative scheme.



Robras Finned Type Radiators are made entirely of brass and so constructed that they will withstand reasonably high steam pressures. As indicated two stamped brass side plates are electrically welded around the edges and down the center in two places. The brass radiating fins are applied at right angles to the surface. Shouldered nipples between sections are firmly screwed into octagonal spacers to prevent distortion of the brass walls. End caps are screwed on to the shouldered nipples at each end section.



Robras Radiators are sectional as described and the sections are assembled in one or two tiers according to the space available. They may be any number of sections deep. By the use of special fittings sections may be connected vertically or horizontally as illustrated.

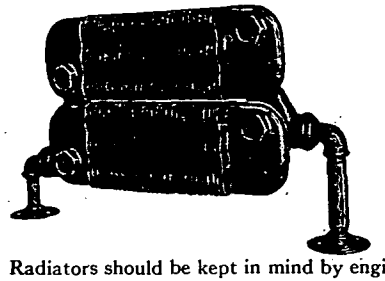
Sections of Robras Radiators are from 18 to 70 inches in length and are conservatively rated from 5½ sq. ft. to 25 sq. ft. so that 100 sq. ft. of Robras Radiator can be set in a space 4 in. deep, 12 in. high and 70 in. long.

The ratings of Robras Radiators have been determined from carefully prepared tests and are guaranteed when radiators are properly installed and other conditions of the heating plant are correct.

To select the proper Robras Radiator for heating a room, the matter of draft head, or flue height of the enclosure is very important as this determines the effectiveness of the installation.

The capacity tables given indicate draft heads from 12 to 60 in. Draft heads greater than 60 in. are not recommended.

For example assume that B.tu. loss of the room amounts to 7200 and a recess available beneath a window is 45 in. long, 4 in. deep and the sill height is 27 in. Deducting 9 in. from the sill height to allow for inlet and outlet grilles leaves 18 in. which is the effective draft-head. To allow for supply and return connections 10 in. will be taken in this case from the length of the recess, leaving 35 in. for the actual radiator.



Referring to the two-tier capacity table, under 18-in. draft-head, we find that 32 in. is the nearest section length and that a 4 section 32-in. radiator will give 31½ sq. ft. The overall depth of this radiator is 3¾ in.

Several important features of Robras Radiators should be kept in mind by engineers, architects and heating contractors:

1—Supply and return tappings are usually horizontal but Robras Radiators can be furnished with tappings for vertical connections from the bottom.

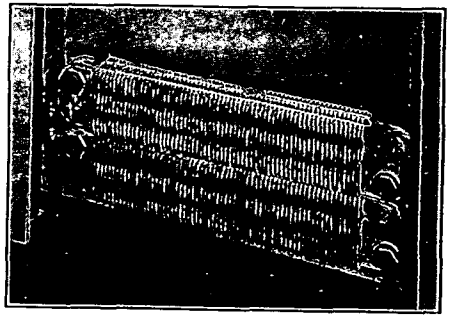
2—Robras Radiators are rated in sq. ft. of equivalent direct radiation making it unnecessary to add any percentage for enclosing them.

3—Top and bottom grilles in the face of the wall are recommended.

4—Robras Radiators are approximately ⅓ the size and only ⅕ as heavy as the old fashioned radiator of equal rating.

5—Robras Radiators can be used with any steam, vapor, or hot water heating system.

6—They are within the walls, out-of-the-way and out-of-sight.



Typical Specification for Robras Radiators

Robras Radiators Furnish and install where shown on plans and called for in the specifications, Robras Radiators of the finned type as manufactured by the ROME BRASS RADIATOR CORPORATION, 1 East 42nd Street, New York City.

All radiators shall be shipped completely assembled with the connections tapped in accordance with the manufacturers' schedule.

All Robras Radiators shall be installed in a horizontal position with the low end 4 in. above the finished floor and shall be pitched in accordance with dimensions furnished by the manufacturers.

Radiators may be supported on standards made of ⅜ in. iron nipples with a floor flange at either end.

Radiator Recesses

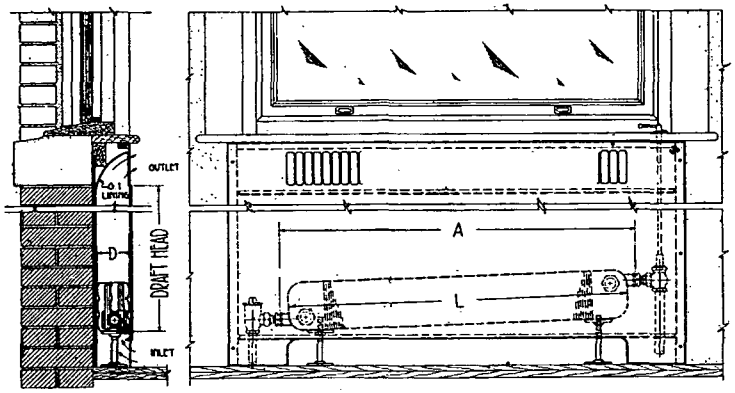
All recesses for Robras Radiators shall be lined with No. 26 gauge sheet metal, backed with approved insulation. Sizes of recesses shall be as shown on plans but general details may be obtained from the ROME BRASS RADIATOR CORPORATION data sheets.

Radiator recesses shall be provided with fronts having face openings above and below the radiator as shown on details, the free area of the bottom opening shall be not less than 30 per cent of the top face area of the radiator. The free area of the top opening shall be not less than 40 per cent of the top face area of the radiator. Free areas of grilles used in top and bottom openings shall not be less than the proportion given above.



Bathroom Units

Each bathroom unit shall be furnished complete with a white lacquered metal cabinet 8 in. high and may be supported by the pipe connections only. (Note that on one pipe steam jobs small angle iron brackets will be required for these units). Robras Bathroom Units shall be so installed as to have the grille at the top.



Typical One Tier ROBRAS 20–20 Installation Showing Front Elevation and Section

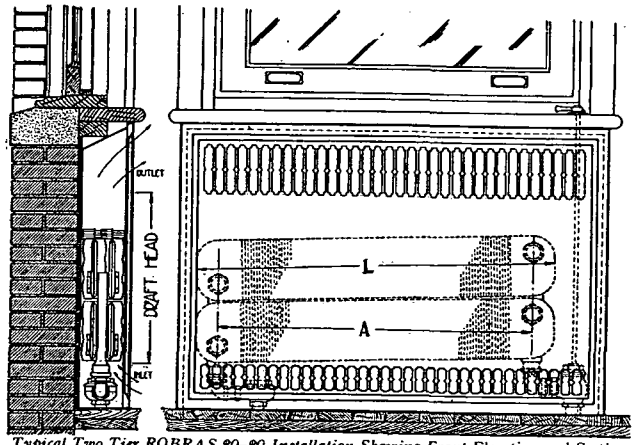
Capacities of Enclosed ONE TIER ROBRAS 20–20 RADIATORS

Capacities are shown in the square foot equivalent of standard direct cast iron radiation. One square foot equals 240 B.t.u. per hour in a 70 deg. room with steam at 215 deg. and one pound pressure.

TABLE NO. 1

L—Section Length		18″		22″		26″		32″		38″		44″		50″		60″		70″	
Total No. of Sections in Rad.	A—Face to Face of Tappings 1″ Tap	19¼″		23¼″		27¼″		33¼″		33¼″		45¾″		51¾″		61¾″		71¾″	
	A—Face to Face of Tappings 1½″ Tap	20½″		24½″		28½″		34½″		40½″		46½″		52½″		62½″		72½″	
	D—Overall Depth of Rad.	B.t.u.	Sq. Ft.	B.t.u.	Sq. Ft.	B.t.u.	Sq. Ft.	B.t.u.	Sq. Ft.	B.t.u.	Sq. Ft.	B.t.u.	Sq. Ft.	B.t.u.	Sq. Ft.	B.t.u.	Sq. Ft.	B.t.u.	Sq. Ft.
12 in. Draft Head																			
2	3¾″	2160	9	2760	11½	3240	13½	4140	17¼	5040	21	5880	24½	6720	28	8160	34	9600	40
3	5¼″	3240	13½	4140	17¼	4860	20¼	6210	25¾	7560	31½	8820	36¾	10080	42	12240	51	14400	60
4	6¾″	4320	18	5520	23	6480	27	8280	34½	10080	42	11760	49	13440	56	16320	68	19200	80
5	8¼″	5400	22½	6900	28¾	8100	33¾	10350	43	12600	52½	14700	61¼	16800	70	20400	85	24000	100
6	9¾″	6480	27	8280	34½	9720	40½	12420	51¾	15120	63	17640	73½	20160	84	24480	102	28800	120
18 in. Draft Head																			
2	3¾″	2280	9½	3000	12½	3600	15	4560	19	5400	22½	6360	26½	7320	30½	8880	37	10440	43½
3	5¼″	3420	14¼	4500	18¾	5400	22½	6840	28½	8100	33¾	9540	39¾	10980	45¾	13320	55½	15660	65¼
4	6¾″	4560	19	6000	25	7200	30	9120	38	10800	45	12720	53	14640	61	17760	74	20880	87
5	8¼″	5700	23¾	7500	31¼	9000	37½	11400	47½	13500	56¼	15900	66¼	18300	76¼	22200	92½	26100	108¾
6	9¾″	6840	28½	9000	37½	10800	45	13680	57	16200	67½	19080	79½	21960	91½	26640	111	31320	130½
24 in. Draft Head																			
2	3¾″	2520	10½	3240	13½	3840	16	4800	20	5880	24½	6960	29	7920	33	9600	40	11280	47
3	5¼″	3780	15¾	4860	20¼	5760	24	7200	30	8820	36¾	10440	43½	11880	49½	14400	60	16920	70½
4	6¾″	5040	21	6480	27	7680	32	9600	40	11760	49	13920	58	15840	66	19200	80	22560	94
5	8¼″	6300	26¼	8100	33¾	9600	40	12000	50	14700	61¼	17400	72½	19800	82½	24000	100	28200	117½
6	9¾″	7560	31½	9720	40½	11520	48	14400	60	17640	73½	20880	87	23760	99	28800	120	33840	141
30 in. Draft Head																			
2	3¾″	2640	11	3360	14	4080	17	5160	21½	6240	26	7320	30½	8400	35	10200	42½	12000	50
3	5¼″	3960	16½	5040	21	6120	25½	7740	32¼	9360	39	10980	45¾	12600	52½	15300	63¾	18000	75
4	6¾″	5280	22	6720	28	8160	34	10320	43	12480	52	14640	61	16800	70	20400	85	24000	100
5	8¼″	6600	27½	8400	35	10200	42½	12900	53¾	15600	65	18300	76¼	21000	87½	25500	106¼	30000	125
6	9¾″	7920	33	10080	42	12240	51	15480	64½	18720	78	21960	91½	25200	105	30600	127½	36000	150
40 in. Draft Head																			
2	3¾″	2880	12	3600	15	4440	18½	5520	23	6720	28	7920	33	9120	38	11040	46	12960	54
3	5¼″	4320	18	5400	22½	7760	27¾	8280	34½	10080	42	11880	49½	13680	57	16560	69	19440	81
4	6¾″	5760	24	7200	30	8880	37	11040	46	13440	56	15840	66	18240	76	22080	92	25920	108
5	8¼″	7200	30	9000	37½	11100	46¼	13800	57½	16800	70	19800	82½	22800	95	27600	115	32400	135
6	9¾″	8640	36	10800	45	13320	55½	16560	69	20160	84	23760	99	27360	114	33120	138	38880	162
50 in. Draft Head																			
2	3¾″	3000	12½	3840	16	4680	19½	5880	24½	7080	29½	8400	35	9600	40	11640	48½	13680	57
3	5¼″	4500	18¾	5760	24	7020	29¼	8820	36¾	10620	44¼	12600	52½	14400	60	17460	72¾	20520	85½
4	6¾″	6000	25	7680	32	9360	39	11760	49	14160	59	16800	70	19200	80	23280	97	27360	114
5	8¼″	7500	31¼	9600	40	11700	48¾	14700	61¼	17700	73¾	21000	87½	24000	100	29100	121¼	34200	142½
6	9¾″	9000	37½	11520	48	14040	58½	17640	73½	21240	88½	25200	105	28800	120	34920	145½	41040	171
60 in. Draft Head																			
2	3¾″	3120	13	3960	16½	4800	20	6120	25½	7320	30½	8640	36	9960	41½	12000	50	14160	59
3	5¼″	4680	19½	5940	24¾	7200	30	9180	38¼	10980	45¾	12960	54	14940	62¼	18000	75	21240	88½
4	6¾″	6240	26	7920	33	9600	40	12240	51	14640	61	17280	72	19920	83	24000	100	28320	118
5	8¼″	7800	32½	9900	41¼	12000	50	15300	63¾	18300	76¼	21600	90	24900	103¾	30000	125	35400	147½
6	9¾″	9360	39	11880	49½	14400	60	18360	76½	21960	91½	25920	108	29880	124½	36000	150	42480	177

Where top outlets are used, decrease amount of required effective radiation 10 per cent and use capacities shown above.



Typical Two Tier ROBRAS 20–20 Installation Showing Front Elevation and Section

Capacities of Enclosed TWO TIER ROBRAS 20–20 RADIATORS

Capacities are shown in the square foot equivalent of standard direct cast iron radiation. One square foot equals 240 B.t.u. per hour in a 70 deg. room with steam at 215 deg. and one pound pressure.

TABLE NO. 2

Section Length—L		18″		22″		26″		32″		38″		44″		50″		60″		70″	
Total No. of Sections in Rad.	Center Supply To A Center Return	14⅛″		18⅛″		22⅛″		28⅛″		34⅛″		40⅛″		46⅛″		56⅛″		66⅛″	
	D—Overall Depth of Rad.	B.t.u.	Sq. Ft.	B.t.u.	Sq. Ft.	B.t.u.	Sq. Ft.	B.t.u.	Sq. Ft.	B.t.u.	Sq. Ft.	B.t.u.	Sq. Ft.	B.t.u.	Sq. Ft.	B.t.u.	Sq. Ft.	B.t.u.	Sq. Ft.
12 in. Draft Head																			
4	3¾″	3480	14½	4320	18	5280	22	6720	28	8160	34	9600	40	10920	45½	13200	55	15600	65
6	5¼″	5220	21¾	6480	27	7920	33	10080	42	12240	51	14400	60	16380	68¼	19800	82½	23400	97½
8	6¾″	6960	29	8640	36	10560	44	13440	56	16320	68	19200	80	21840	91	26400	110	31200	130
10	8¼″	8700	36¼	10800	45	13200	55	16800	70	20400	85	24000	100	27300	113¾	33000	137½	39000	162½
12	9¾″	10440	43½	12960	54	15840	66	20160	84	24480	102	28800	120	32760	136½	39600	165	46800	195
18 in. Draft Head																			
4	3¾″	3960	16½	4920	20½	6000	25	7560	31½	9240	38½	10800	45	12360	51½	15000	62½	17640	73½
6	5¼″	5940	24¾	7380	30¾	9000	37½	11340	47¼	13860	57¾	16200	67½	18540	77¼	22500	93¾	26460	110¼
8	6¾″	7920	33	9840	41	12000	50	15120	63	18480	77	21600	90	24720	103	30000	125	35280	147
10	8¼″	9900	41¼	12300	51¼	15000	62½	18900	78¾	23100	96¼	27000	112½	30900	128¾	37500	156¼	44100	183¾
12	9¾″	11880	49½	14760	61½	18000	75	22680	94½	27720	115½	32400	135	37080	154½	45000	187½	52920	220½
24 in. Draft Head																			
4	3¾″	4200	17½	5400	22½	6600	27½	8280	34½	9960	41½	11760	49	13440	56	16320	68	19200	80
6	5¼″	6300	26¼	8100	33¾	9900	41¼	12420	51¾	14940	61¼	17640	73½	20160	84	24480	102	28800	120
8	6¾″	8400	35	10800	45	13200	55	16560	69	19920	83	23520	98	26880	112	32640	136	38400	160
10	8¼″	10500	43¾	13500	56¼	16500	68¾	20700	86¼	24900	103¾	29400	122½	33600	140	40800	170	48000	200
12	9¾″	12600	52½	16200	67¾	19800	82½	24840	103½	29880	124½	35280	147	40320	168	48960	204	57600	240
30 in. Draft Head																			
4	3¾″	4680	19½	5880	24½	7200	30	9000	37½	10920	45½	12840	53½	14640	61	17880	74½	21000	87½
6	5¼″	7020	29¼	8820	36¾	10800	45	13500	56¼	16380	68¼	19260	80¼	21960	91½	26820	111¾	31500	131¼
8	6¾″	9360	39	11760	49	14400	60	18000	75	21840	91	25680	107	29280	122	35760	149	42000	175
10	8¼″	11700	48¾	14700	61¼	18000	75	22500	93¾	27300	113¾	32100	133¾	36600	152½	44700	186¼	52500	218¾
12	9¾″	14040	58½	17640	73½	21600	90	27000	112½	32760	136½	38520	160½	43920	183	53640	223½	63000	262½
40 in. Draft Head																			
4	3¾″	5040	21	6240	26	7680	32	9600	40	11640	48½	13800	57½	15720	65½	19200	80	22440	93½
6	5¼″	7560	31½	9360	39	11520	48	14400	60	17460	72¾	20700	86¼	23580	98¼	28800	120	33660	140¼
8	6¾″	10080	42	12480	52	15360	64	19200	80	23280	97	27600	115	31440	131	38400	160	44880	187
10	8¼″	12600	52½	15600	65	19200	80	24000	100	29100	121¼	34500	143¾	39300	163¾	48000	200	56100	233¾
12	9¾″	15120	63	18720	78	23040	96	28800	120	34920	145½	41400	172½	47160	196½	57600	240	67320	280½
50 in. Draft Head																			
4	3¾″	5280	22	6600	27½	8040	33½	10080	42	12240	51	14400	60	16440	68½	20040	83½	23520	98
6	5¼″	7920	33	9900	41¼	12060	50¼	15120	63	18360	76½	21600	90	24660	102¾	30060	125¼	35280	147
8	6¾″	10560	44	13200	55	16080	67	20160	84	24480	102	28800	120	32880	137	40080	167	47040	196
10	8¼″	13200	55	16500	68¾	20100	83¾	25200	105	30600	127½	36000	150	41100	171¼	50100	208¾	58800	245
12	9¾″	15840	66	19800	82½	24120	100½	30240	126	36720	153	43200	180	49320	205½	60120	250½	70560	294
60 in. Draft Head																			
4	3¾″	5400	22½	6720	28	8280	34½	10320	43	12600	52½	14760	61½	16800	70	20640	86	24240	101
6	5¼″	8100	33¾	10080	42	12420	51¾	15480	64½	18900	78¾	22140	92¼	25200	105	30960	129	36360	151½
8	6¾″	10800	45	13440	56	16560	69	20640	86	25200	105	29520	123	33600	140	41280	172	48480	202
10	8¼″	13500	56¼	16800	70	20700	86¼	25800	107½	31500	131¼	36900	153¾	42000	175	51600	215	60600	252½
12	9¾″	16200	67½	20160	84	24840	103½	30960	129	37800	157½	44280	184½	50400	210	61920	258	72720	303

Where top outlets are used, decrease amount of required effective radiation 10 per cent and use capacities shown above.

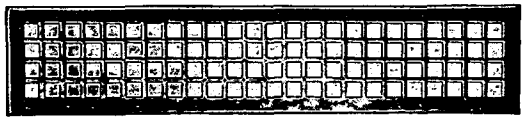
The Auer Register Co.

Cleveland, Ohio

MANUFACTURERS OF REGISTERS, FACES AND GRILLES FOR HEATING AND VENTILATING; WROUGHT METAL GRILLES FOR CONCEALING AND PROTECTING RADIATION

Cold Rolled Steel, Sheet Brass, and Bronze, any Size

10 Gauge and Lighter Steel in all Standard Finishes, 12 Gauge most popular

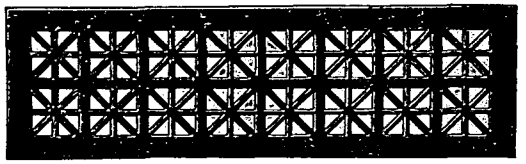


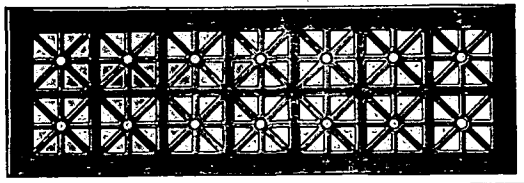
PLAIN LATTICE DESIGN

Design No.	Holes	Bars	Opening
8A	1/2" sq.	1/4"	50%
5A	3/4" sq.	1/4"	64%
3A	7/8" sq.	1/4"	70%
9A	1" sq.	1/4"	75%
10A	1 3/4" sq.	1/4"	85%

UNION JACK—Design No. 12A

Squares	Bars	Multiples
2 1/2"	1/4"	2 3/4" sq.
2 1/2"	1/2"	3" sq.
3"	3/8"	3 3/8" sq.
3"	1/2"	3 1/2" sq.
3 3/8"	3/8"	4" sq.
3 3/8"	3/8"	4 1/4" sq.





GRECIAN CROSS

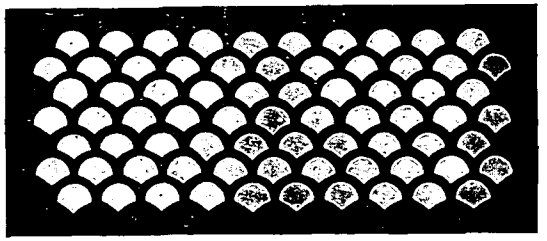
Design No. 7A, 50% Opening

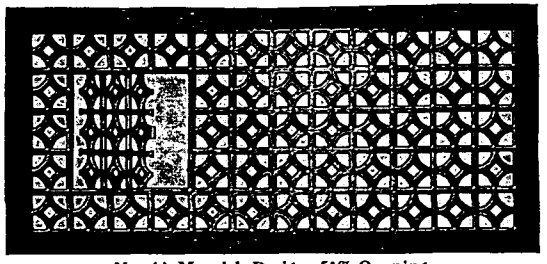
Squares	Bars	Multiples
3"	1/8"	3 1/8" sq.
3"	1/4"	3 1/4" sq.
3"	3/4"	3 3/4" sq.

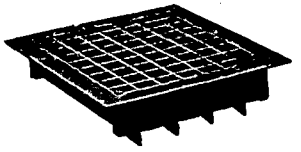
SHELL DESIGN

Design No. 13A, 50% Opening

Perforations	Bars	Multiples
1 3/4"	1/4"	2" sq.







LOUVER REGISTERS

In all sizes and finishes for all purposes.

No. 4A Moorish Design, 51% Opening
Openings 1 3/4 in. Bars 1/4 in. Multiples 2 in. square

Invisible doors for access to radiator valves can be incorporated.
All grilles can be made into registers with operating or stationary louvers.

Tuttle & Bailey Mfg. Co.

Established 1846

441 Lexington Avenue, New York

BOSTON—36 Portland St.
CHICAGO—1123 West 37th St.
KANSAS CITY—704 East 18th St.
LOS ANGELES—Central Bldg.

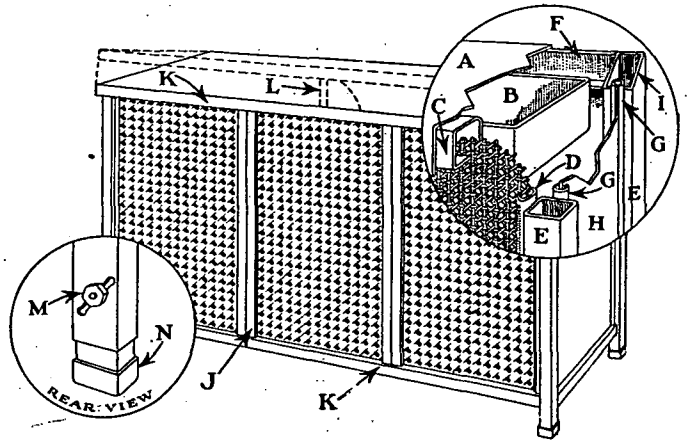
TUTTLE & BAILEY MFG. CO. OF CANADA, LTD., BRIDGEBURG, ONTARIO, CAN.

REGISTERS AND GRILLES FOR HEATING AND VENTILATING

Brochure "Grilles" on request—complete information on Ferrocraft, Ornamental and Stamped Metal Grilles, with Special Designs, Tables for establishing sizes and full size Details showing methods of installing.

RADIATOR CABINETS AND SHIELDS

The rapidly growing demand for radiator concealment should have the sympathetic attention of Architects and Engineers and our design and construction meet both technical and artistic requirements.



Showing Construction of Villa Style

A. Hinged top of No. 14 gauge furniture metal.
B. Humidifying pan of galvanized iron.
C. Reinforced steel tubing, slotted to hold grilles securely.
D. Steel moulding, slotted to hold grilles securely.
E. Reinforced steel tubing.
F. Heavy formed steel crossbar makes back as rigid as front. Top is hinged to this crossbar.
G. Steel moulding, slotted to hold ends.
H. Ends solid (ends and back are No. 18 or No. 20 gauge, depending on size of Cabinet).
I. Corners mitred.
J. Mullions of steel tubing slotted to hold grilles securely.
K. Crossbars of steel tubing slotted to hold grilles securely.
L. Swivel "catch" to hold top open for increased circulation.
M. Slot and nut on back of legs for adjusting height.
N. Adjustable leg.

Raleigh Style has rounded ends with grilles, otherwise construction is same as the Villa.

Other styles of Formed Furniture Metal—all joints welded.

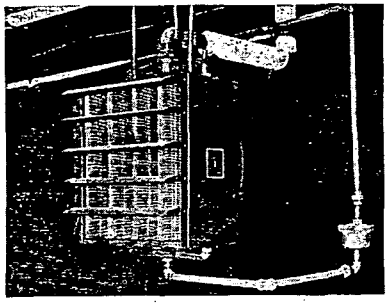
All of our Radiator Cabinets and Shields are made to order for exact fit with wide range of Grilles and Finishes.

Armstrong Machine Works

352 Maple Street **Three Rivers, Mich.**

District Sales Offices in 36 Cities

Exclusive Manufacturers of Armstrong Steam Traps

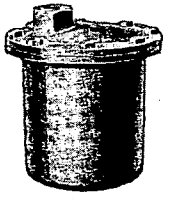


A No. 30 Armstrong Trap under Unit Heater

Armstrong Steam Traps

Armstrong steam traps are made in types and sizes to meet all condensate draining requirements. They are available for pressures up to 600 lb. pulsating pressures, high temperatures, acid conditions and for special services of all kinds. They are ideally suited for draining unit heaters, and steam heating systems.

Armstrong traps have many noteworthy advantages. They automatically discharge entrapped air with the condensate. They can not become air bound. They are positive in operation—the valve is either wide open or tightly closed—wire drawing and subsequent erosion of valves and seats are eliminated. Being water sealed at all times, no live steam can escape. The unique construction gives a large capacity for a small size. Because of their small size, their cost is low and installation is a simple matter. No special fittings or supports are necessary. The sturdy construction and special wear-resisting parts insure long life and a minimum of maintenance.



No. 31

The Nos. 30 and 31 traps are especially adapted for low or high pressure radiation up to 125 and 150 lb. respectively. Their low cost permits free use. A trap on each unit insures perfect drainage. A thermic unit is incorporated in each trap which holds the valve open until the trap becomes hot. This assures rapid heating of equipment.



No. 30

The Nos. 2, 3 and 4 Armstrong Traps are the standard type for general service up to 300 lb. pressure.

The Nos. 30S to 4S Armstrong Traps are for service where there are pulsating pressures due to reciprocating engines and pumps drawing steam from a line.

For pressures up to 600 lb., steel bodies are used. The standard Armstrong Traps with steel bodies are designated as Nos. 42, 43 and 44. The special traps are numbered 42S, 43S and 44S. Traps for higher pressures can be furnished on special order.

In Regard to Capacities

Because of smaller valves and orifices, traps for high pressures have less capacity than the same trap for lower pressures. Always state maximum pressure when ordering steam traps.

SIZES AND CAPACITIES OF ARMSTRONG STEAM TRAPS

No.	Diam. In.	Height In.	Weight Lb.	Pipe Size, Inlet and Outlet In.	Capacities at 30-lb. Press.				Price List
					Linear Ft. 1-in. Pipe	Radiation Sq. Ft.	Gal. per Hour	Lb. per Hour	
30	5⅝	4⅜	5	½	1842	614	92	768	$ 9.25
30 Special	5¼	8	11	½	1842	614	92	768	14.25
31	5⅝	6¼	7½	½	3234	1078	162	1348	15.00
31 Special	5¼	10	13½	½	3234	1078	162	1348	20.00
2	6¼	10	18	¾	7377	2459	370	3074	20.75
2 Special	6½	13¼	32	¾	7377	2459	370	3074	27.75
3	8½	14	45	1 or 1¼	29514	9838	1481	12297	38.00
3 Special	8½	18½	67	1 or 1¼	29514	9838	1481	12297	45.00
4	10	10¾	74	1½ or 2	51774	17258	2599	21572	70.00
4 Special	10	22	114	2	51774	17258	2599	21572	90.00

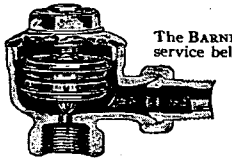
Write for discounts. See Catalogue *E* for capacities from 0 to 600-lb. pressure.

Barnes & Jones

128 Brookside Avenue, **Jamaica Plain, Boston, Mass.**

New York Office: 101 Park Avenue

Barnes & Jones Improved Modulation Vapor and Vacuum Systems of Steam Heating: Modulating Radiator Valves, Thermostatic Radiator Traps, Thermostatic Traps for medium and high pressures, Condensators (Boiler Return Traps), Blast Traps, Drip Traps, Vent Traps, Strainers, Damper Regulators, Gages.



Barnes & Jones Service



The BARNES & JONES organization offers an advisory and consulting service believing that the manufacturer of a heating system often is in the best position to give practical assistance in the solution of heating problems. On request, members of our staff will consult with and advise engineers, contractors or users as to the most advantageous manner in which BARNES & JONES apparatus can be installed and operated or adapted to special installations. When desired, our Service Department will furnish installation details and work with engineers, contractors or users to gain the best results in installation or operation.

Factory Tested

Each and every appliance used in the BARNES & JONES Modulation Vapor and Vacuum Heating Systems is tested, inspected and adjusted at our own factory before shipment, to meet all the conditions which 30 years' experience in the development of heating apparatus have shown us are likely to arise.

Barnes & Jones Modulation Valves

Sizes and Models—Made in the angle type, in sizes from ⅛ to 1½ in. Standard model has lever handle. Has renewable disc seat.

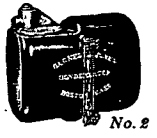
Size Valve, Inches	Capacity, Sq. Ft.
½	30
¾	60
1	100
1¼	180
1½	250

Barnes & Jones Condensators

For returning the water of condensation to the boiler from open return line systems independently of boiler pressure, without any change in operating conditions, and without air binding, or admitting steam to the return side of the system.



No. 1



No. 2

Barnes & Jones Vent Traps

The air from a BARNES & JONES Vapor System is discharged to the atmosphere through a BARNES & JONES Vent Trap. This vent trap is equipped with a float valve to prevent the discharge of water and also with a ball check valve which allows the free discharge of air but prevents its return into the system, thus enabling BARNES & JONES Vapor Systems to operate in many cases under vacuum conditions, with a resultant saving in fuel.



Vent Trap

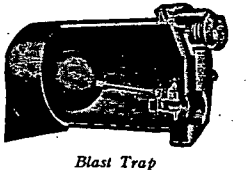
Barnes & Jones Thermostatic Radiator Traps

This valve is made in ½, ¾, 1 and 1¼-in. sizes. The ½-in. size is made in four types: angle, straightway, right-hand corner and left-hand corner patterns. The ¾, 1 and 1¼-in. sizes are made in the angle and straightway patterns. The ½-in. size unless otherwise specified is made with ¾-in. outlets, thus avoiding the use of all ½-in. pipe and reducing fittings.

Size Valve, Inches	Water per Hour, Lb.	Sq. Ft. Coils	Sq. Ft. C.I. Radiation
½	30	100	125
¾	80	240	320
1	200	600	800
1¼	400	1200	1600

Barnes & Jones Blast Traps

Combination float and thermostatic traps with an air and water capacity large enough to take care of the condensation from the largest vento stacks, dry kiln coils, hot water heaters and other units condensing large quantities of steam at low pressures.



Blast Trap

Size Trap, Inches	Capacity, Lb. Water per Hour
¾	600
1	1000
1¼	2000
1½	3000
2	4000
2½	5000

The Bishop & Babcock Sales Co., Cleveland, Ohio

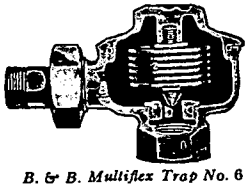
4901-4915 Hamilton Avenue, N.E.

BALTIMORE, MD.....Building Service Co., 404 St. Paul St.
BOSTON, MASS.....Tierney Wilson Co., Metropolitan Bldg.
BRIDGEPORT, CONN.,
C. J. S. Heating Supply Corp., 655 Fairfield Ave.
CHATTANOOGA, TENN., S. Roberts, 404 Temple Court Bldg.
CHICAGO, ILL.....The Bishop & Babcock Sales Co.
DENVER, COLO.....The Daly Co., 1425 Sixteenth St.
DETROIT, MICH., Wolley Eng. Sales Co., 506 Donovan Bldg.
MINNEAPOLIS, MINN.....Continental Sales Co.
NASHVILLE, TENN.....Ryan Sales Co., 922 Stahlman Bldg.
NEW YORK, N. Y.....The Bishop & Babcock Sales Co.
OKLAHOMA CITY, OKLA.....Federal Steam Specialty Co.
PHILADELPHIA, PA., Alexander & McDevitt, 1725 Sansom St.
RICHMOND, VA.....Virginia Equipment & Supply Co.
SAN FRANCISCO, CALIF., Walter S. Leland, 532 Natoma St.
SCOTIA, N. Y.....F. E. Dwyer, 25 Wallace Ave.
SPOKANE, WASH., R. L. Nelson, 507 Empire State Bldg.

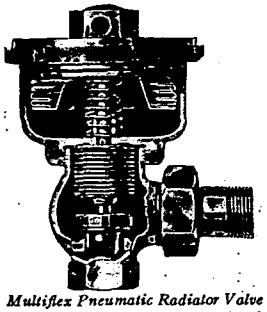
Heating Specialties—Temperature Control—Ventilating Equipment—Unit Heaters



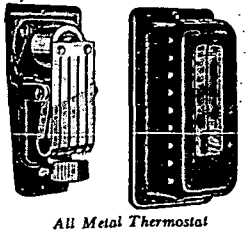
Special Modulation Valve



B. & B. Multiflex Trap No. 6



Multiflex Pneumatic Radiator Valve

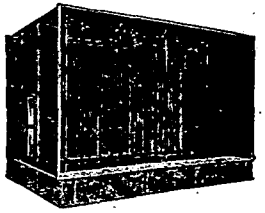


All Metal Thermostat

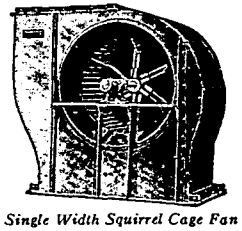
Bishop & Babcock manufactures a complete line of Heating and Ventilating Equipment. Its products comprise all devices and apparatus used in up-to-date vacuum and vapor Heating Systems, Temperature Control and Ventilating Systems. It is entirely practical for an engineer and architect to standardize with **Bishop & Babcock** apparatus, thus insuring a uniformity in design and operation not to be found in equipment of varied manufacture.

Bishop & Babcock has been manufacturing heating, ventilating and temperature control apparatus for many years, its installations including many of the most prominent buildings in all parts of the country.

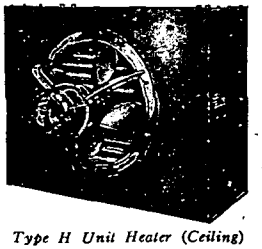
Our Engineering Data Book, pocket edition, will be mailed upon request.



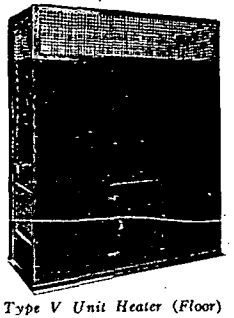
Type B Massachusetts Air Washer



Single Width Squirrel Cage Fan



Type H Unit Heater (Ceiling)



Type V Unit Heater (Floor)

Combustion Specialties Corporation

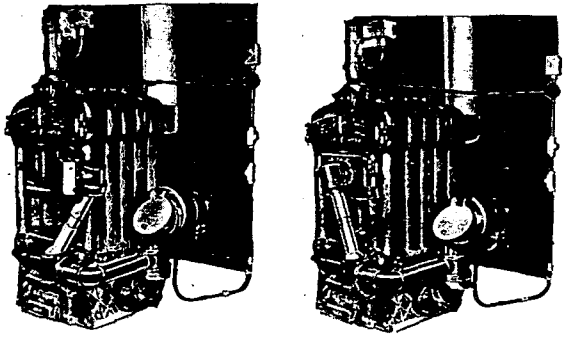
250 West 54th St., New York

Manufacturers

BURN BUCKWHEAT **DRAFT-BALANCER** LOWER COSTS

DRAFT **COMBUSTO** SYSTEM

For all types and sizes of Heating and Hot Water Supply boilers in Apartment Houses, Buildings, Churches, Garages, Greenhouses, Institutions, Schools and Residences.



DRAFT-BALANCER installation with Mercoid Automatic Control and Manual Cut-Out Switch showing operation of Double Ball and Socket Joints with Telescoping Sleeve

Specifications:

Consists of cast iron or aluminum housings bolted directly to ash-pit of boiler. Damper door over intake controls volume of air delivered by Sirocco fan wheel. Fan is direct connected to Century, G. E., or Leland motor. A portion of the air delivered by the fan is diverted over the fire by piping or metal flexible hose from orifice in adapter casting to double ball and socket telescoping coupling. This air is delivered to diffuser on inside of fire-door and sprayed over the fire for consuming the monoxide gas as it is distilled from the coal. Operation is governed by Mercoid or Contactor type of automatic control.

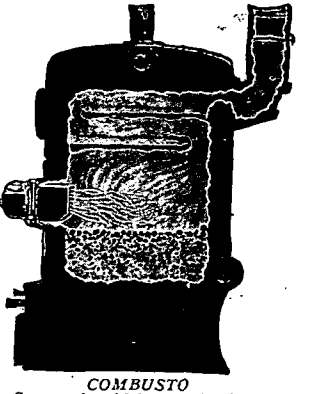
The DRAFT-BALANCER enables the *burning of Buckwheat No. 1 coal without increasing the tonnage consumed or attention necessary to the fire* over that required with the use of Egg, Stove, Nut, or Pea anthracite. This is due to the unique feature of creating a balanced air supply over and under the fire, together with the carefully studied-out engineering principles which assure positive, accurate, quiet operation.

WHAT COMBUSTO IS: To quote the late Walter S. Timmis, past president of the *American Society of Heating & Ventilating Engineers:* "COMBUSTO is a system carefully studied, tested and developed for each individual different case and provides means for supplying the necessary diffused and heated air (oxygen) over the fire to properly complete in the second stage the combustion begun in the fuel bed by distillation of gases."

WHAT COMBUSTO DOES: "COMBUSTO is of cast iron cellular structure, the air is heated on passing through this structure and is then discharged through a large number of small apertures over the fire bed. The amount of air thus admitted having been carefully computed for the required conditions, the result is practically perfect combustion, which to the user of COMBUSTO results in—

Economy of fuel
Fewer firings
Complete combustion of fuel, hence—
A finer ash and reduction of clinker
Elimination of coal gases
Means for producing a steady even heat."

STYLES: COMBUSTO is manufactured in 28 basic styles—each style is capable of adjustment to meet specified conditions. Suitable styles are manufactured for practically any type of heating plant and for all sizes and grades of fuel. Definite estimates can be submitted at once if manufacturer's name and number of boiler is sent to us.



COMBUSTO
Saves coal and labor—maintains even heat with less draft
Aids draft with undersize chimneys

G. M. Davis Regulator Company

407 MILWAUKEE AVENUE :-: CHICAGO, ILL.

New York Office, 71 Fulton Street

Manufacturers of Automatic Valve Specialties

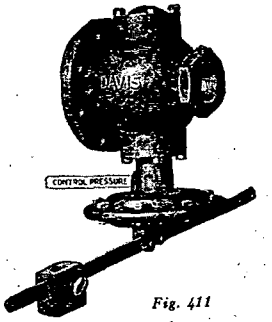


Fig. 411

Pressure Regulator—Diaphragm Type

Large diaphragm insures sensitive action under low service pressures as required in heating.

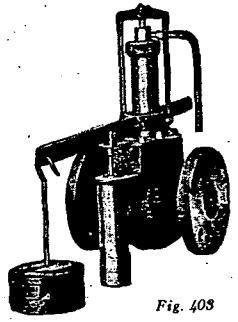


Fig. 403

Pressure Regulator—Piston Type

Automatically makes any pressure reduction. Has visible action and may be hand tested.

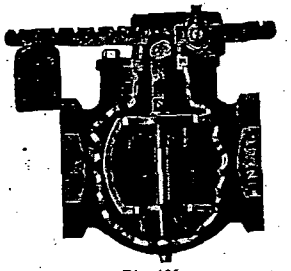


Fig. 425

Back Pressure Valve

A noiseless, double ported, semi-balanced valve for maintaining exhaust steam pressure of 20 lb. or less.

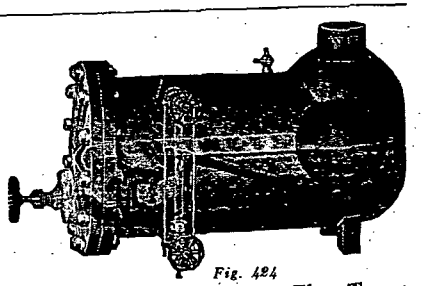


Fig. 424

Steam Trap—Continuous Flow Type

Duplex balanced valves give unusually large capacity. Works on any pressure without alteration. Will discharge into a vacuum line.

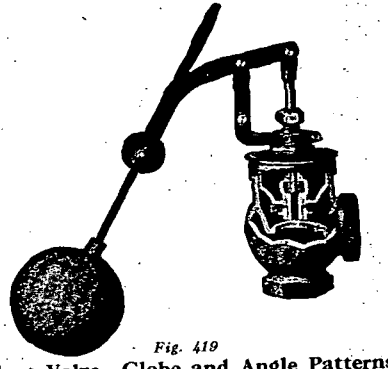


Fig. 419

Float Valve—Globe and Angle Patterns

Used on makeup line to open tank—maintains constant level. Has no internal packing—closes tight. Can not stick.

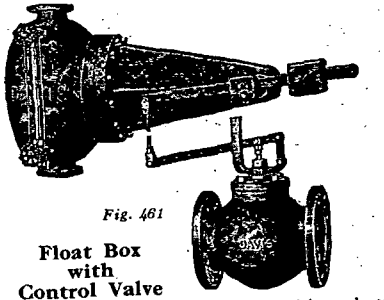


Fig. 461

Float Box with Control Valve

An accessible unit for controlling the level in a closed tank. Made also for distant control.

C. A. Dunham Company

General Offices: Dunham Bldg., 450 East Ohio St., **CHICAGO, ILL.**

Factories: Marshalltown, Iowa, Michigan City, Indiana and Toronto, Ont., Can.

Eastern Division Offices	Central Division Offices	Western Division Offices
101 Park Avenue, New York, N.Y.	450 E. Ohio Street, Chicago, Ill.	617 W. 7th Street, Los Angeles, Calif.

BRANCH SALES OFFICES

Albany, N.Y., 91 State St.
Allentown, Pa., 11 S. 5th St.
Atlanta, Ga., Forsyth Bldg.
Baltimore, Md., 206 Water St.
Bangor, Maine, 104 Exchange St.
Bellingham, Wash., 1107 State St.
Birmingham, Ala., 507-509 Twenty-second St., North
Boston, Mass., 136 Federal St., Boston 9
Buffalo, N.Y., 232 Delaware Ave.
Chattanooga, Tenn., Volunteer Bldg.
Cheyenne, Wyo., 510 W. 25th St.
Chicago, Ill., 450 East Ohio St.
Cincinnati, Ohio, Union Trust Bldg.
Clarksburg, W.Va., Exponent Bldg.
Cleveland, Ohio, Un on Trust Bldg.
Columbus, Ohio, Comstock Bldg.
Dallas, Texas, Dallas Nat'l Bk. Bldg.
Davenport, Iowa, Security Bldg.
Denver, Colo., 414 West Colfax Ave.
Des Moines, Iowa, Old Colony Bldg.
Detroit, Mich., 2938 E. Grand Blvd.
El Paso, Texas, 401 N. Santa Fe St. (P.O. Box 240)
Gary, Ind., 1842 W. 5th Ave.
Gloversville, N.Y., 21 So. Main St.
Grand Rapids, Mich., Michigan Trust Bldg.
Greenville, S. Car., P.O. Box 563
Harrisburg, Pa., 2216 N. Fifth St.
Huntington, W.Va., 215 Hines Bldg.
Indianapolis, Ind., Board of Trade Bldg.
Ironwood, Mich., The Albert Bldg.
Johnstown, Pa., 244 Market St.
Joliet, Ill., P.O. Box 1086
Kalispell, Mont., 1 Whipps Blk.
Kansas City, Mo., City Bank Bldg., 18th and Grand Ave.
Kingston, Pa., 101 S. Walnut St.
Los Angeles, Calif., 617 W. 7th St.
Louisville, Ky., Starks Bldg.
Memphis, Tenn., 15 So. 4th St.
Milwaukee, Wis., Empire Bldg.
Minneapolis, Minn., 132 So. 10th St.
New Haven, Conn., 107 Grand Ave.
New Orleans, La., New Orleans Bank Bldg.
New York, N.Y., 101 Park Ave.
Newark, N.J., 972 Broad St.
Omaha, Neb., Peters Trust Bldg.
Peoria, Ill., Peoria Life Bldg.
Philadelphia, Pa., 1500 Walnut St.
Providence, R.I., 49 Westminister St.
Pittsburgh, Pa., May Bldg.
Portland, Ore., Buyers Bldg.
Pueblo, Colo., Colorado Bldg.
Quincy, Ill., 628-638 Jersey St.
Rochester, N.Y., Mercantile Bldg.
Rocky Mount, N. Car., P.O. Box 1076
St. Louis, Mo., 3605 Laclede Ave.
Salt Lake City, Utah, Dooly Bldg.
San Antonio, Texas, Travis Bldg.
San Francisco, Calif., Monadnock Bldg.
Seattle, Wash., 415 Lenora St.
Spokane, Wash., 614 Peyton Bldg.
Syracuse, N.Y., O.C.S.B. Bldg.
Toledo, Ohio, 1918 Vermont Ave.
Trenton, N.J., 219 E. Hanover St.
Tulsa, Okla., Cosden Bldg.
Washington, D.C., Munsey Bldg.
White Plains, N.Y., 199 Main St. (Bar Bldg.)
Wichita, Kas., 1100 E. Douglas Ave.

C. A. Dunham Co., Ltd.,
1523-41 Davenport Road,
Toronto, 4, Ont., Canada.

Sales Offices: Calgary, Alta.; Halifax, N.S.; Montreal, Que.; Ottawa, Ont.; Quebec, Que., St. Johns, Nfld.; Toronto, Ont.; Winnipeg, Man.; Vancouver, B.C.

C. A. Dunham Co., Ltd.
(of The United Kingdom)
18 St. Thomas St., S.E. 1, London, England.

Agencies: Birmingham, Eng.; Leeds, Eng.; Liverpool, Eng.; Newcastle-on-Tyne, Eng.; Glasgow, Scotland; Belfast, Ireland; Paris, France; Gothenburg, Sweden; Wellington, N.Z.

The DUNHAM HEATING SERVICE

This Service is delivered through over Branch and Local Sales Offices throughout the United States, Canada and the United Kingdom. These Branch and Local sales offices bring Dunham Heating Service as close to your office as your telephone. Consult your telephone directory for the address of our office in your city. An engineer will counsel with you on any project.

DUNHAM DIFFERENTIAL VACUUM HEATING SYSTEM

A clear conception of the underlying principle is necessary in order to obtain the best results possible. The engineer should know what the Dunham Differential Vacuum Heating System really is, in order to take full advantage of its possibilities.

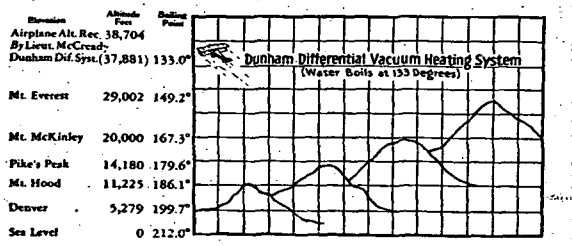


Fig. 5

The system uses steam as a heating medium. This steam is supplied from the boiler direct or through controlled valves to the radiators at variable temperatures from 133 deg. up to 212 deg. and higher if so required. The 133 deg. temperature corresponds to 25 in. of vacuum at sea level, and 212 deg. to zero on the gauge.

By furnishing steam at this wide range of temperatures, it is possible to vary the heat output of the radiation thus preventing overheating. For instance, in mild weather, steam is supplied at a low temperature, therefore the radiator will give off only a slight amount of heat (in fact one can hold his hand on the radiator). As the weather gets colder higher temperature steam is furnished until finally in severe weather there may be a pressure on the radiation instead of the high vacuum used in mild weather. See Figs. 1 and 2.

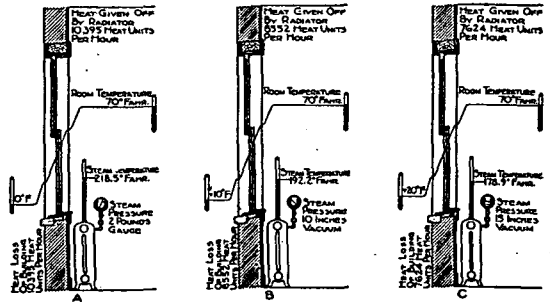


Fig. 1

HEAT CONTROL.—This illustration shows how the room temperature is maintained uniformly under changing weather conditions, by varying the steam pressure so that the heat given off by the radiator equals the heat lost by the building.

It is generally known that water boiling at sea level will generate steam at 212 deg. while up in the higher altitudes where the atmospheric pressure is less, water will boil at much lower temperatures. See Fig. 3. For instance, in Denver which is at an altitude of 5279 ft. above sea level the water will boil and generate steam at about 199.7 deg. fahr.

The same pressure conditions are duplicated in the boiler and system of the Differential Vacuum Steam Heating System. The temperature of the steam is governed by the Dunham control equipment and the Dunham Differential Vacuum Pump which removes the air from the system thereby reducing the pressure on the water in the boiler, or causing the steam to expand through Reducing Valves when they are used.

The term "Differential" is applicable because a relatively constant differential in pressure between the radiator and the return is maintained, so that the air and water will constantly flow out of the radiators. The steam is induced to completely fill them. Due to this "Differential" complete circulation is obtained and the radiators throughout the building are heated uniformly. The "cooler" steam gives a "mild heat," which prevents overheating. This is more healthful, and less destructive to decorations and furniture, than the "hot" steam used in ordinary types of systems.

This system is simple, easy to design and install and very economical in operation.

The system was in the transition process from theory to practical application for many years. There was involved in this problem a complete revolutionizing of the art of heating with the altering of Mechanical Appliances so as to function under the new conditions.

There are many outstanding advantages in such a system.

First and foremost it affords a solution of the problem of preventing waste of fuel through overheating of buildings including loss from excessive window ventilation in mild weather when only a minimum amount of heat is required.

Mild weather constitutes approximately 95

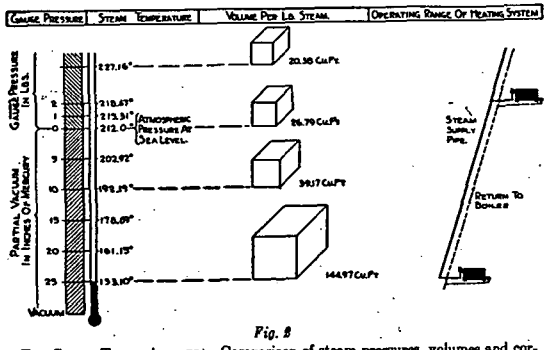


Fig. 2

THE STEAM TABLE APPLIED.—Comparison of steam pressures, volumes and corresponding boiling points. Steam is produced at lower temperatures and circulated just as easily at 20 in. of vacuum as at 2 to 3 lb. gauge pressure.

per cent of the heating season in most localities.

Past experience indicates that this system will effect a fuel saving of 25 per cent or more compared with previous types of steam heating systems.

The Dunham Differential Vacuum Heating System fully meets the needs of a climate where variations in temperature occur during the heating season.

Fig. 4 clearly shows how marked the daily fluctuations in outdoor temperature may be. These changes may be as high as 40 deg. within a period of 24 hours.

Note the wide variations in the daily temperatures, as shown by the heavy irregular curve marked (1). This curve is an actual picture of each day's maximum and minimum temperatures during the heating season of 1926-27.

Curve (2) indicates the average mean temperature over a period of 54 years. Curves (3) and (4) are the highest and lowest temperatures recorded during this period.

A heating system must be designed with sufficient radiation to heat the building satisfactorily on the coldest winter day. Curve (4) governs what heating engineers term the "design basis" for a heating system in or around Chicago. Now note how curve (3) reveals the demand for a flexible heating system—one which will not overheat in mild weather, and yet will provide ample warmth when lowest temperatures are encountered. Weather Bureau records show that there were but 35 hours when temperatures were zero and lower during the winter of 1926-27 and but 131 hours when the temperature dropped to 10 deg. above zero or lower. On March 16, 1927, temperature in Chicago soared to 71, yet during March in other years there have been days when zero temperatures were reached!

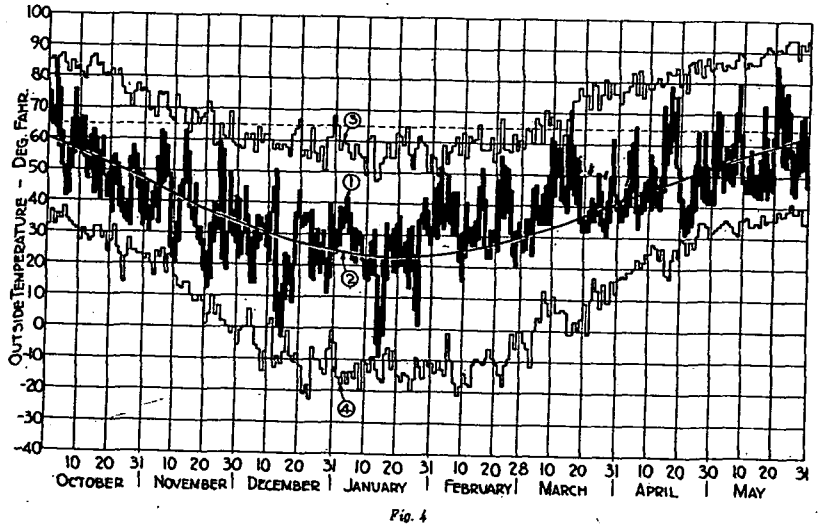


Fig. 4

Official temperatures for Chicago's winter weather, season 1926-27, a record typical of a large portion of the country.

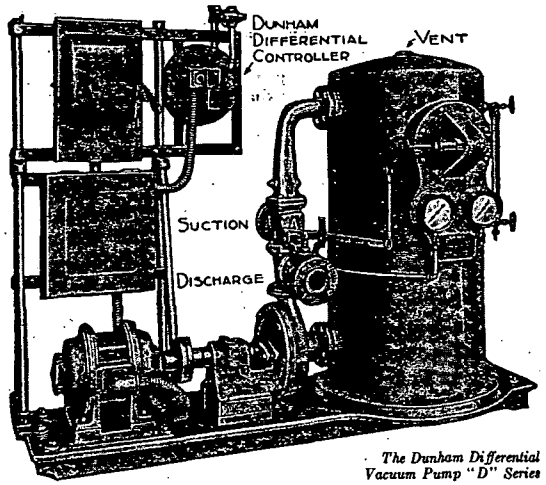
Method of Heat Control

The principal function of this system is to prevent excess heat losses from a building by maintaining a uniform desired temperature in the building and no more. There are three distinct methods of accomplishing this:

(a) Manual Control, using two Dunham Sub-Atmospheric Reducing Valves, adjusting these so as to furnish a uniform sufficient flow of Sub-Atmospheric Steam. This method and method B are used in the "D" series system.

(b) Automatic Control, by the additional function of an automatic valve controlled from one or more Room Thermostats. This automatic valve takes the place of the larger of the Sub-Atmospheric Reducing Valves.

(c) Automatic operation, as used in the "DH" series system and also in the "D" series, in which the boiler is controlled by a Room Thermostat.



The Dunham Differential Vacuum Pump "D" Series

"D" SERIES SYSTEM

As applied to the heating of office buildings, hotels, apartment houses, hospitals, schools and groups of buildings. For use on any system with more than 2,000 square feet of equivalent direct radiation.

The Dunham Differential Vacuum Pump operates on the Jet Exhauster principle. The Dunham Exhauster is a special design and has great air and vapor handling capacity. Under high pressures water is supplied from the receiving tank to the exhauster by a motor driven enclosed impeller type centrifugal pump of high efficiency.

The pump exhausts air and water from return piping under very high vacuums and discharges condensate to the boiler. It is a completely assembled compact unit ready for piping and wiring connections.

The Differential Controller of the Pump keeps the vacuum in return substantially higher than that carried in the radiation when the system is operating under vacuum conditions. As a result, the circulation of steam becomes positive and makes it possible to utilize this vacuum.

The system fills with low temperature steam and the radiator traps operate exactly as they do when the system is operating at a pressure equal to or greater than atmosphere. If the severity of the weather requires more heat it is obtained by increasing the pressure of the steam in the system, thus increasing the steam temperature correspondingly.

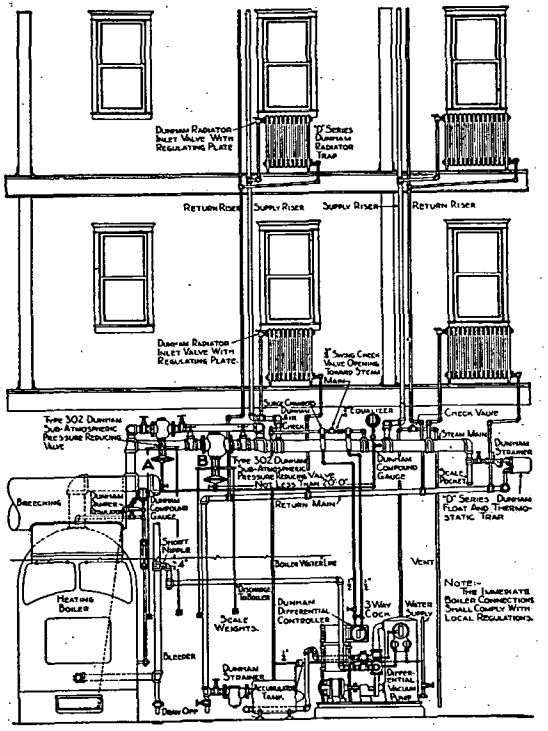


Fig. 5

Dunham Differential System, "D" Series, Manual Control (Method 1)

Control Methods "D" Series System

Method 1

The Manual Control Method is illustrated by Fig. 5, in which the building temperature is controlled by adjusting manually the Two Dunham Sub-Atmospheric Pressure Reducing Valves, the operator being guided by a thermometer in the building. A long distance indicating, or recording thermometer can be used to advantage, making the manual control very convenient.

The valve marked "A" is for mild weather operation, while valve "B" is for use in cold weather. In severe weather both valves can be put in service.

Method 2

The Automatic Control Method is illustrated, Fig. 6. In this method the Control Valve "C" is operated from a room thermostat and takes the place of the large Dunham Sub-Atmospheric Pressure Reducing Valve, "B" in Fig. 5, making the control of heat supply to building automatic. Valve "A" in this case will supply the minimum heating load and temperature while Control Valve "C" will supply the balance of heat in order to maintain the building temperature.

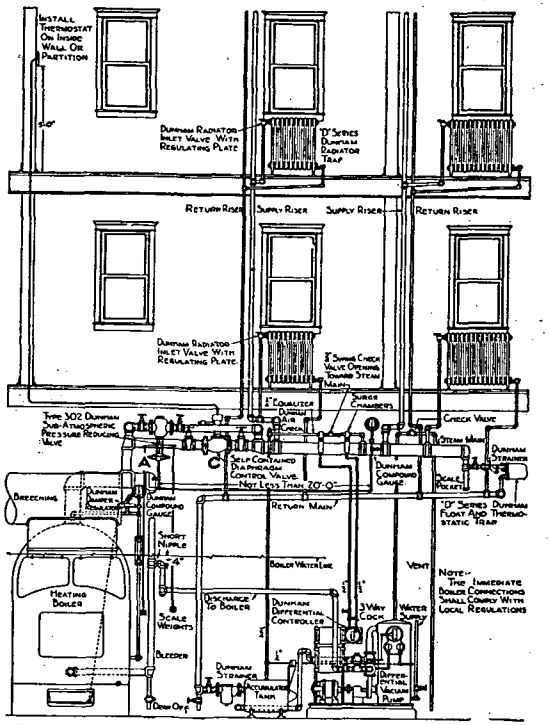
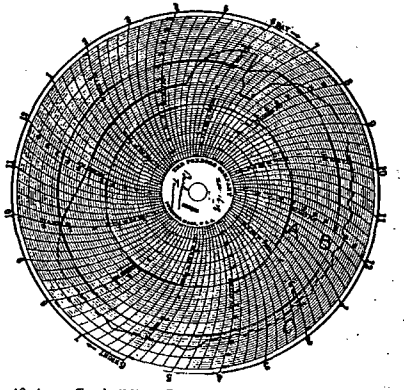
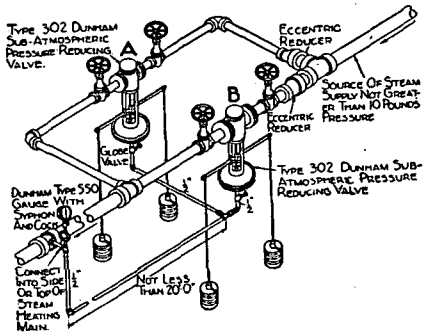


Fig. 6—Dunham Differential System "D" Series, Automatic Control (Method 2)

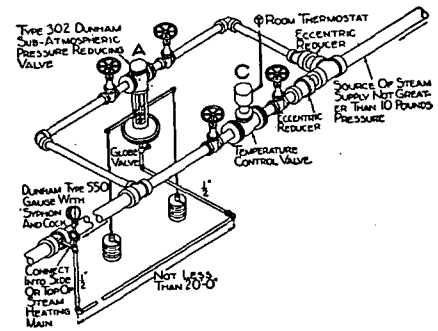


Operating Chart, 40-story office building, Detroit, Mich. "A", recorded outside temperature. "B", inside temperature. "C", steam pressure (vacuum) on steam heating main.



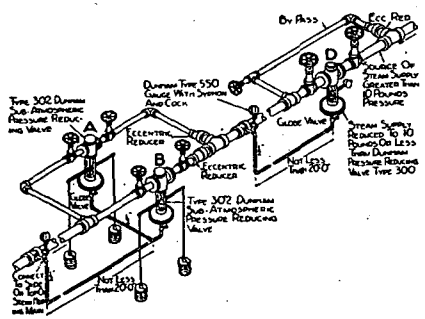
Application 1

Application 1 is a manually controlled Differential System using steam at not more than 10 lb. initial gauge pressure. For higher initial pressures see Application 3. Two Sub-Atmospheric Pressure Reducing Valves are used as shown. Valve "A" supplies steam in mild weather. The second valve, "B" supplies steam in cold weather. In extreme weather both valves may be used if necessary.



Application 2

Application 2 is an automatically controlled system on which a temperature controlled valve "C," operated from a thermostat is substituted for valve "B." The thermostat must be placed in a typical room on the most exposed side of the building at the point most remote from boiler measured along the steam piping. The thermostat location must represent the average building temperature and heat requirements. The temperature control equipment may be one of the several commercial types according to the requirements of the building. When such an arrangement is used the valves should be installed as shown.



Application 3

Application 3 is a manually controlled system on which the source of steam supply is greater than 10 lb. The pressure reducing valve "D" should be installed as shown.

Application 3 may be modified by substituting a temperature control valve for valve "B."

Sub-Atmospheric Reducing Valves should be located in the piping, so that the Engineer can conveniently stand on the boiler room floor, or control room floor, and from there shift the scale weights which vary the Pressure or Vacuum carried in the heating main. The scale weights to be hung on extension rods of ¼-in. pipe of proper length so that weights come 6 ft. from the floor.

On very large installations it will be of advantage to provide a separate set of Control Valves for each Main Branch so that the heat to each main portion of the building can be controlled most economically. A separate pump must be used for each zone.

Pressure Reducing Valves can be omitted on low pressure oil, gas fired, and coal fired installations having blower or stoker if each method is controlled by a room thermostat.

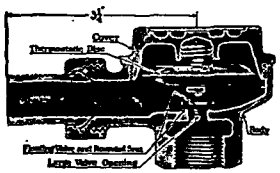
Drip traps must always be used on drain points of steam mains whenever Pressure Reducing Valves are used.

DUNHAM DIFFERENTIAL RADIATOR TRAPS



Angle Pattern — *Straightway Pattern* — *Right Hand Pattern* — *Left Hand Pattern*

All traps used in connection with the Dunham Differential Vacuum Heating System are known as "D" series. They function uniformly over a range of pressures and temperatures from 25 in. of vacuum to 25 lb. gauge pressure. The accompanying chart shows performance of a Dunham D1 Radiator Trap over this range of pressures and temperatures.



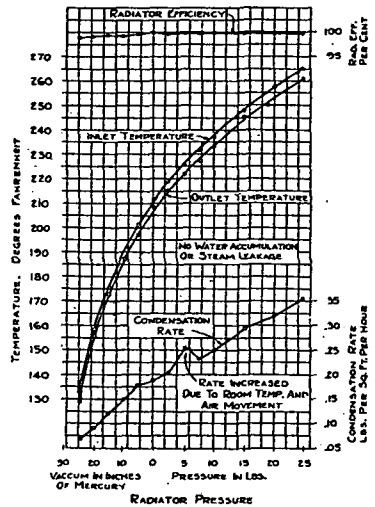
Sectional View of Dunham Thermostatic Radiator Trap

The outlet temperature in this test bore the same relation to the inlet temperature of the radiator over the entire pressure range of 25 in. vacuum to 25 lb. gauge, a pressure substantially 37½ lb. higher than the 25 in. vacuum. Graph shows the constant uniformity of temperature between steam and return lines throughout the entire range of pressures.

The radiator efficiency was consistently high (almost 100 per cent and there was no steam leakage or water accumulation.

The condensation rate in the 5.0 lb. gauge test increased due to air movement in the room and a low room temperature, the trap responded immediately by passing the increased condensate under this condition without leakage of steam.

The test was conducted on a 3 col. 38 in.—100 sq. ft. radiator.



The Dunham traps conform with the standard dimension of 3¼ in. from center of trap to end of union nipple, as adopted by *The Heating and Piping Contractors' National Association* for ½ in. radiator traps.

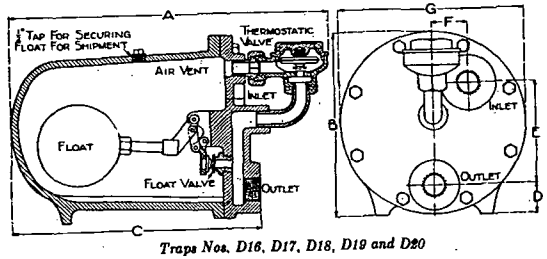
Float and Thermostatic Traps—"D" Series

25-in. vacuum to 25 lb. gauge pressure.

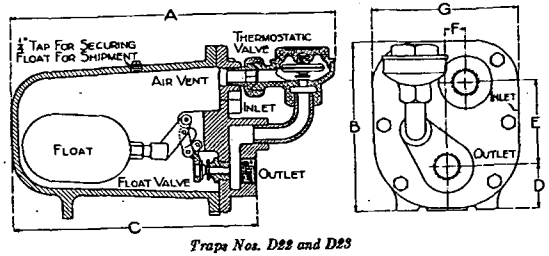
Sizes are distinguished by size number preceded by a capital "D."

Trap No.	Size of Tapping Inches	Capacity Sq. Ft. Equivalent Direct Radiation	Net Wght. Lbs.	Dimensions, Inches						
				A	B	C	D	E	F	G
D22	¾	1600	14	11¼	6⅜	9⅛	1⅜	3¼	¾	5½
D23	1	2800	15	11¼	6⅜	9⅛	1⅜	3¼	¾	5½
D16	¾	3600	24	14⅛	7⅞	10½	1⅜	4¼	1½	7⅞
D17	1	5200	24	14⅛	7⅞	10½	1⅜	4¼	1½	7⅞
D18	1¼	8000	33	15½	9⅜	12⅛	2	4⅞	1¾	9½
D19	1½	11500	33	15½	9⅜	12⅛	2	4⅞	1¾	9½
D20	2	14000	42	19¾	11⅞	15½	2¼	6⅞	1⅜	9⅛

Capacities given are based upon a condensation rate of ¼ lb. per square foot of cast iron direct radiation per hour, at a pressure differential of one inch of mercury, which is equivalent to ½ lb. per square inch. All traps have right hand female tappings.



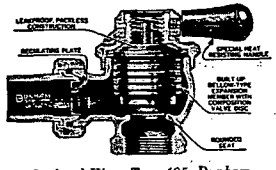
Traps Nos. D16, D17, D18, D19 and D20



Traps Nos. D22 and D23

A Dunham Strainer should be installed on the inlet side of each Drip Trap. Trouble caused by dirt in the traps will thus be eliminated.

DUNHAM PACKLESS VALVES WITH REGULATING PLATE



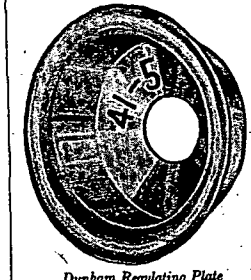
Sectional View, Type 105, Dunham Packless Radiator Valve with Regulating Plate

Dunham Packless Radiator Valves with Regulating Plate must be used on all radiators to secure proper balance. Either Type 105 (Lever handle) or Type 145 (Wheel handle) may be used.

The valve is made packless by means of the bellows construction, consisting of a series of corrugated phosphor bronze diaphragms which permit the free up and down movement of the spindle and valve disc. This construction obviates the use of springs, packing or stuffing boxes of any kind and entirely prevents the leakage of steam, air or water. The prevention of air leakage into the radiators is a most important factor, for such leakage will destroy the vacuum. It further has the advantage that no steam, water or dirt can come in contact with the thread of the valve spindle. It assures easy turning of handle at all times.

The Regulating Plate Type 192 distributes the correct proportion of steam to each radiator during such times as the system is not filled with steam as in the heating-up period.

The plate is inserted in the valve as shown in sectional view. The plate orifice being calibrated to the number of feet of radiation in each radiator.



Dunham Regulating Plate

The use of the Regulating Plate simplifies many things which have been serious barriers to progress in the art of heating. Without this plate the resistance the steam encounters in flowing from the boiler to the radiator would not be the same for each radiator.

Under conditions either of pressure or of vacuum a 26 sq. ft. radiator should heat no more rapidly than a 100 sq. ft. radiator irrespective of the relative location of the two with reference to the boiler. In actual practice with no provision for interposing resistance to the vapor flow there will be irregularity in heating each respective radiator.

Interposing the Regulating Plates evens up this inequality of flow when starting up the system. After all radiators are filled with steam the Regulating Plate does not further perform a function.

Specifications "D" Series, Dunham Differential Vacuum Heating System

As Applied to the Heating of Large Buildings

1. GENERAL CONDITIONS.—The general conditions governing this work shall be those established as standard by the American Institute of Architects which shall apply hereto.

2. CONSTRUCTION AND MATERIAL.—The heating apparatus, proposed herewith, includes the furnishing, delivery and erection on the premises of all necessary material

and labor, which shall be first class in all particulars, and in accordance with the specifications and plans.

3. INSPECTION.—The Heating Contractor must at all times allow the C. A. Dunham Company's Representative to come on the job for the purpose of inspection and must lend any assistance necessary to expedite and complete the work. Any instructions given by the C. A. Dunham Company's Representative and confirmed in writing regarding changes to make system conform to plans or specifications and details shall be considered a part of this specification.

4. BOILER.—The steam boiler shall be a..... with guaranteed rating for..... sq. ft. of radiation installed upon suitable foundation, and equipped with all necessary connections and trimmings, including a safety valve set to blow at 10 lb. pressure, a Dunham Compound Gauge 15 lb. x 30 in. vacuum and a 7-in. Dunham Damper Regulator. (Omit Regulator on gas fired and automatic oil fired installations.)

5. SMOKE PIPE.—Connect boiler to chimney with suitable black iron smoke pipe gauge..... Size to be as recommended by Boiler Manufacturer. Smoke pipe must be provided with hand stop damper.

6. PRESSURE CONTROL VALVES.—On all systems not equipped with full automatic control of fire, install two Dunham Sub-Atmospheric Control Valves of size shown on plans, with necessary gate valves and a Dunham 15 lb. x 30 compound gauge, all in accordance with manufacturer's details and instructions.

7. PIPE AND FITTINGS.—Furnish and erect with tight connections all necessary piping of sizes shown on plans and run as indicated, supported and properly graded to insure free and noiseless circulation. Use fittings of cast iron of standard quality. The ends of all pipes shall be reamed or filed. Proper provision must be made for expansion. Use graphite and oil for making up all pipe joints applied to male thread only. Provide for expansion of mains and risers by loop type expansion joints and swing connections in mains wherever possible. In other cases provide approved all-metal packless expansion joints. Piping to be properly anchored.

8. All steam tappings in boiler shall be connected full size of tapping into a steam header which shall be dripped to the return header through a bleeder. All spring pieces to steam and return mains shall be taken off the top of mains at 45 deg. On down-feed systems take the spring pieces from the bottom of steam main at 90 deg.

9. The end of each steam main and each drip point shall be drained, through a gate valve, Dunham Strainer, and "D" Series Dunham Trap as indicated on plans.

Drip the bottom of each down-feed riser through "D" Series Dunham Trap into dry return main. No lift connections shall be used at drip points.

10. Grade steam mains ½ in. in 10 ft. Grade return mains and drip mains 1 in. in 10 ft. All steam supply branches such as spring pieces, offsets in steam risers and runouts to radiators shall in each case be installed one size larger than the vertical pipes to which they connect and shall be given as much grade as possible. ½ in. per foot is preferable.

11. Return mains shall be connected together into the accumulator tank of Dunham Differential Vacuum Pump as shown in detail furnished by manufacturer. Lift connections must not be used except between pump and accumulator tank.

12. Risers are to be run concealed or in the open as directed by the architect. Each down-feed steam riser must be dripped into the return through a "D" Series Dunham Trap. Install traps as instructed by manufacturer. All concealed piping must be tested and made tight at 15 lb. water pressure before being concealed and covered.

13. All union connections, flanges, packing nuts on gate and globe valves and on gauge glass of boiler must be drawn up tight so as to prevent air leaking into system when under a high vacuum. This work must be performed after system is completed and while it is working with a vacuum in both steam and return lines.

14. FLOOR PLATES, SLEEVES.—Furnish approved floor and ceiling plates, protecting sleeves on all pipes passing through floors or finished partitions.

15. DIFFERENTIAL VACUUM PUMP.—Furnish and install one (or Duplex) Dunham Differential Vacuum Pump of "D" series size....., having a differential rating of..... sq. ft. of equivalent direct radiation. The pump (or pumps) shall be installed, connected and wired in accordance with manufacturer's instructions.

15A. DOMESTIC HOT WATER AND BLAST HEATER.—Condensation from this equipment shall be returned to boiler by other means than Dunham Differential Vacuum Pump.

16. CHECK VALVES.—Check valves shall be horizontal swing type with brass disc, best grade obtainable. They shall be installed where called for by the plans, and in accordance with accompanying details. They shall be tested for tightness.

17. RADIATION.—*Furnish and install radiation as* shown on the plans. There shall be..... sq. ft. of direct radiation of approved make. All radiators must be provided with ¾-in. top inlet tapping and with ½-in. eccentric bushing in the return tapping. All air valve tappings shall be plugged.

18. RADIATOR TRAPS, "D" SERIES, TEMPORARY ELBOWS AND VALVES.—Each radiator shall be provided with a Dunham Temporary Elbow loaned by the manufacturer and shall be installed at outlet end of radiator to facilitate the thorough cleaning of the radiator. After the System has been cleaned, a Dunham "D" Series Radiator Trap of suitable capacity shall replace this elbow. A Dunham Packless Radiator Valve with Dunham Regulating Plate shall be installed at inlet connection, according to manufacturer's instructions. The plates shall not be inserted in the valves until after the system has been cleaned, but before final test is made.

19. PAINTING.—All exposed piping in finished rooms, and all radiators shall be given a priming coat of flat paint and thereafter painted or enameled as directed by architect. All pipe joints and all uncovered piping in basement, front and other exposed parts of boiler shall be painted one coat of black asphaltum when the system is hot and under a vacuum. The finishing coat of paint must be applied when the entire system is under vacuum, so that paint will fill up leaks.

20. COVERING.—Cover all steam mains and their spring pieces with four-ply, 1 in. thick asbestos sectional covering and fittings with asbestos cement. Cover all steam and return risers and other piping run concealed in outside walls with two-ply, ½ in. thick asbestos sectional covering. Cover boiler as specified by boiler manufacturer.

21. FINISHING UP.—Thoroughly blow down and clean out system under a steam pressure of 5 lbs., allowing condensate to be wasted to sewer. Operate system a week with Temporary Elbows installed on radiators. After this period then surface blow-off the boiler, as follows:

Remove the safety valve and connect a temporary blow-off pipe to the safety valve tapping, extending it outside or to some suitable drain. Shut off all radiator valves or valves in main. Fill the boiler with water to top of gauge glass. Build a very hot fire and blow steam and water out through the safety valve tapping and pipe connected thereto. Fire hard with not more than 10 lb. pressure on the boiler. Supply cold water constantly in at bottom of the boiler. Continue this for six hours. At the end of the period, close the water feed valve, draw the fire quickly, open blow-off at bottom of boiler and entirely drain the boiler, replace the safety valve. Fill the boiler slowly after it becomes cold.

Remove the Dunham Temporary Elbows and install in their place the Dunham Traps. Install the Dunham Regulating Plates in the radiator valves.

22. TEST.—The System when finished and cleaned shall be tested for tightness as directed by C. A. Dunham Company's Representative. Contractor shall furnish labor and material for performing test.

23. GUARANTEE.—The Heating Contractor shall guarantee the apparatus installed to circulate steam thoroughly through every radiator without noise, with a vacuum of 15 in. in steam main. If the apparatus shall fail to accomplish this guarantee by reason of any defect developing within the period of one full heating season and that defect is due to faulty material or poor workmanship, the Heating Contractor shall remedy such defect at his own cost within reasonable time after notice thereof.

24. FINALLY.—Nothing herein contained can be construed to relieve the Heating Contractor from making good and perfect work in all usual details of construction, and he will be held responsible to provide and furnish necessary material and to perform all necessary labor and to bear all expenses incidental to the satisfactory completion of the work.

Specifications, "DH" Series Dunham Differential Vacuum Heating System

As Applied to the Heating of Residences

1. GENERAL CONDITIONS.—

2. CONSTRUCTION AND MATERIAL.—

3. INSPECTION.—

(*Paragraphs 1, 2 and 3 same as "D" Series Specifications.*)

4. BOILER.—The steam boiler shall be a..... with guaranteed rating for.....sq. ft. of direct radiation installed upon suitable foundation and in accordance with manufacturer's setting instructions. It shall be equipped with all necessary connections and trimmings, including a safety valve set to blow at 10 lb. pressure, a Dunham Compound Gauge 15 lb. x 30 in. vacuum and a 10-in. Dunham Damper Regulator. (Omit Regulator on gas fired and automatic oil fired installations.)

5. SMOKE PIPE.—Connect boiler to chimney with suitable iron smoke pipe same size as boiler smoke outlet. Smoke pipe must be provided with approved Dunham Check Damper and hand stop damper between check damper and boiler. (On gas and automatic oil fired installations omit Dunham Check Damper.)

6. PIPE AND FITTINGS.—Furnish and erect with tight connections all necessary piping of sizes shown on plans and run as indicated, supported and properly graded to insure free and noiseless circulation. Use fittings of cast iron of standard quality. The ends of all pipes shall be reamed or filed. Proper provision must be made for expansion. Use graphite and oil for making up all pipe joints applied to male thread only.

7. All steam tappings in boiler shall be connected full size of tapping into a steam header which shall be dripped to the return header through a bleeder. All spring pieces to steam and return mains shall be taken off the top of mains at 45 deg.

8. The end of each steam main shall be dripped as indicated on the plans by means of a drip line to boiler, properly vented through Dunham "D1" Trap in accord with details furnished by manufacturer.

9. Grade steam mains ½ in. in 10 ft. Grade return mains and drip mains 1 in. in 10 ft. All steam supply branches such as spring pieces, offsets in steam risers and runout to radiators shall in each case be installed one size larger than the vertical pipes to which they connect and shall be given as much grade as possible. ½ in. per foot is preferable.

10. Return mains shall be connected to the Dunham Differential Vacuum Pump as shown in detail furnished by manufacturer.

11. Risers are to be run concealed or in the open as directed by the architect. All concealed piping must be tested and made tight at 15-lb. water pressure before being concealed and covered.

12. All union connections, flanges, packing nuts on gate and globe valves and on gauge glass of boiler must be drawn up tight so as to prevent air leaking into system when under a high vacuum. This work must be performed after system is completed and while it is working with a vacuum in both steam and return lines.

13. FLOOR PLATES, SLEEVES.—Furnish approved floor and ceiling plates and protecting sleeves on all pipes passing through floors or finished partitions.

14. THERMOSTATIC CONTROL.—Contractor shall furnish and install where shown on plans a Type 77 Minneapolis Honeywell Thermostat or other approved with D. S. Damper Motor and Switch according to Manufacturer's instruction. (If Thermostatic Control equipment is being supplied with oil or gas burner under another contract, then this Contractor shall connect Differential Vacuum Pump to the Switch of Thermostatic Control.)

15. DIFFERENTIAL VACUUM PUMP AND AIR ELIMINATOR.—Furnish and install a DH2A Dunham Differential Vacuum Pump. The pump shall be installed and connected in accordance with manufacturer's instructions and details. The necessary electric wiring between pump and differential control, shall be connected to Thermostatic equipment in accordance with manufacturer's instructions and in conformity with all local regulations.

Furnish and install in accordance with manufacturers' instructions a Dunham Air Eliminator, Type 220B. Install a Dunham Air Check, Type 222, in a tee from vent opening of Eliminator.

16. CHECK VALVES.—
17. RADIATION.— } *Same as "D" Series Specifications.*

18. RADIATOR TRAPS, "D" SERIES, TEMPORARY ELBOWS AND VALVES.—Each radiator shall be provided with a Dunham Temporary Elbow loaned by the manufacturer and shall be installed at outlet end of radiator to facilitate the thorough cleaning of the radiator. After the System has been cleaned, a Dunham "D" Series Radiator Trap of suitable capacity shall replace this elbow. A Dunham Packless Radiator Valve with Dunham Regulating Plate shall be installed at inlet connection according to manufacturer's instructions. The plates shall not be inserted in the valves until after the system has been cleaned, but before final test is made.

19. PAINTING.—
20. COVERING.—
21. FINISHING UP.— } *Same as "D" Series Specifications.*

22. TEST.—The System when finished and cleaned shall be tested for tightness by filling it with water to its very top. Pockets of air in the piping or radiators must be vented so as to allow water to enter. The water shall be left standing in the system at least four hours after all leaks have been made tight, when final test and inspection in presence of Dunham Representative shall be made for leaks. The contractor must take precaution to guard against damage from freezing during test.

23. GUARANTEE.—The Heating Contractor shall guarantee the apparatus installed to circulate steam thoroughly through every radiator without noise, with a vacuum of 15 in. in steam main. If the apparatus shall fail to accomplish this guarantee by reason of any defect developing within the period of one full heating season and that defect is due to faulty material or poor workmanship, the Heating Contractor shall remedy such defect at his own cost within reasonable time after notice thereof.

24. FINALLY.—Nothing herein contained can be construed to relieve the Heating Contractor from making good and perfect work in all usual details of construction, and he will be held responsible to provide and furnish necessary material and to perform all necessary labor and to bear all expenses incidental to the satisfactory completion of the work.

PRODUCTS

In addition to the Dunham Differential Vacuum Heating System hereinbefore described the Dunham Line consists of specialties for use in connection with **the Dunham Home Heating System; The Dunham Return System and the Dunham Vacuum Return Line System—all two-pipe systems, and the Dunham Air Line System for use in connection with one-pipe steam systems.**

These specialties are Radiator Traps; Float and Thermostatic Traps; Air Line Valve; Return Traps; Medium Pressure Traps; Packless Radiator Valves; Pressure Reducing Valves; Vacuum Pump Governors; Air Eliminators; Air Check; Dirt Strainers; Air Vents; Damper Control; Gauges.

In addition to the Dunham Differential Vacuum Pump already described, we build a full line of Vacuum Return Line Pumps, Condensation Pumps and Receivers; Centrifugal Pumps.

Bulletins

Bulletins of standard architectural size with detailed information covering each Dunham Product and System, including roughing-in dimensions, will be furnished on request.

Hoffman Specialty Co., Inc.

Waterbury, Conn.

GENERAL SALES DEPARTMENT

25 West 45th Street, **New York, N.Y.**

HOFFMAN VALVES and CONTROLLED HEAT EQUIPMENT

HOFFMAN VENTING VALVES

In the Hoffman line there is a specially designed venting valve for every type of steam heating system. The basic principle used in the design of all Hoffman venting valves is that of an all-metal thermostatic member, with one or more flexible diaphragms, containing a volatile or heat sensitive fluid which causes valve action upon slight temperature changes.

Hoffman valves have a wide pressure range in which they operate with the same degree of accuracy, for the internal fluid pressure in the thermostatic member maintains a constant relationship with the external steam pressures throughout the whole range of pressure for which each valve is intended.

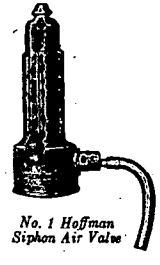
Hoffman valves are automatic, non-adjustable and guaranteed to properly function for a period of five years from date of installation when installed and operated under normal conditions for which designed.

VENTING VALVES FOR ONE-PIPE SYSTEMS

ALL METAL—NON-ADJUSTABLE—THERMOSTATIC

The No. 1 Hoffman Siphon Air Valve is designed for systems of the one-pipe gravity type, to vent all air from radiators without loss of steam. After contact of water with the valve the siphon drains all water from the valve and venting occurs without the slightest "spit" even if the radiator is under pressure.

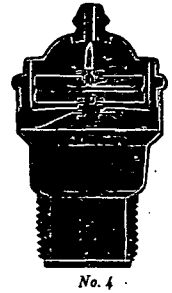
Radiator connection, ⅛ in. Maximum guaranteed operating pressure, 10 lb. Furnished with special short siphons for narrow pattern radiators.



No. 1 Hoffman Siphon Air Valve

The No. 4 is used in venting mains, risers, vento stacks, coils, etc. All air is freely vented through a ⅛ in. vent port without steam loss, but valve does not close against water.

Standard connection, ¾ in., can also be supplied with ¼ in. connection. Maximum guaranteed operating pressure, 10 lb.

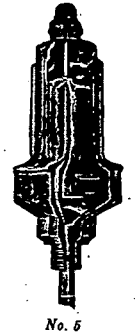


No. 4

The No. 5 is particularly adapted for use in venting: Ends of steam or dry return mains; Indirect radiators; Blast or "Vento" stacks; Hot-water generators; Dryers and drums, etc.

The basic principle is the same as the No. 1 Valve, having separate channels for air and water which are only found in Hoffman Valves.

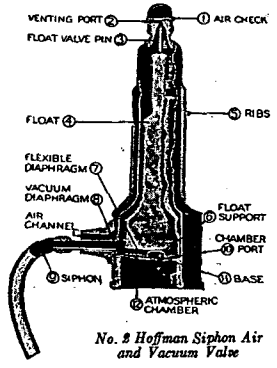
Pipe connection, ⅜ in.; vent port for less than 3 lb. is $\frac{1}{16}$ in.; for 3 lb. and over is $\frac{1}{8}$ in. Unless otherwise ordered, will be shipped with $\frac{1}{8}$ in. port. Maximum guaranteed operating pressure, 10 lb.



No. 5

Write for Descriptive Circular—
The Watchman of the Coal Pile

VENTING VALVES FOR ONE-PIPE VACUUM SYSTEMS



No. 2 Hoffman Siphon Air and Vacuum Valve

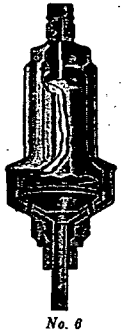
The No. 2 Siphon Air and Vacuum Valve is similar in construction to the No. 1, but in addition, when the radiator is once freed from air, return of air through the vent port is prevented. Through its use an ordinary one-pipe steam system may be changed into a vacuum type.

Radiator connection, ⅛ in. Maximum guaranteed operating pressure, 10 lb. Furnished with special short siphons for narrow pattern radiators.

How the Hoffman No. 2 Vacuum Valve Operates—Normally venting port (2) through which air escapes is wide open until steam comes in contact with the float (4). Then the heat sensitive fluid in the float, the thermostatic member, is changed to gaseous state expanding the flexible diaphragm (7), raising the float and closing vent port.

If the radiator is shut off or for any reason steam contact ceases, the diaphragm contracts, and the float drops. But no air can re-enter the valve because the air check (1) makes the port a one-way street—air can go out but none can come back. So with the continuation of condensation of steam and prevention of air return a vacuum is formed in the system. Atmospheric pressure exerted through chamber port (10) causes diaphragm (8) to lift the float (4) and keep port closed.

In other words, the air check acts as a vacuum starter, prevents return of air for a short period until the vacuum formed in the valve permits atmospheric pressure, acting through port (10) to force diaphragm (8) upward, raising the float and doubly closing the vent port.

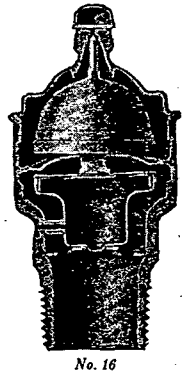


No. 6

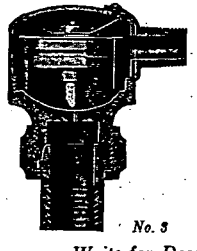
The No. 6 Float Air and Vacuum Valve is similar in design and application to the No. 5 with the additional feature of the Air Check or Vacuum starter above vent port and vacuum diaphragm in base. Used for venting ends of mains, vento stacks, etc., where water is liable to be present.

Pipe connection, ⅜ in.; vent port for less than 3 lb. is $\frac{3}{16}$ in.; for 3 lb. and over is $\frac{1}{16}$ in. Unless otherwise ordered, will be shipped with $\frac{1}{16}$ in. port. Maximum guaranteed operating pressure, 10 lb.

The No. 16 Air and Vacuum Valve is used for venting ends of steam and dry return mains. Valve is 3⅜ in. high overall, permitting installation in lines close to ceiling. It has the special Hoffman feature, the combined check valve and vacuum diaphragm for preventing return of air to system. Pipe connection, ¾ in. Vent port $\frac{1}{16}$ in. dia. Maximum operating pressure, 10 lb.



No. 16



No. 3

The No. 3 Hoffman Air Line Valve is specially designed for Air Line, or as they are frequently termed "Paul" Systems. It is sensitive in action and closes the instant steam fills the radiator.

Radiator connection, ⅛ in.; Air Line connection, ¼ in. Maximum guaranteed operating pressure, 10 lb.

THE HOFFMAN VALVE LOCK

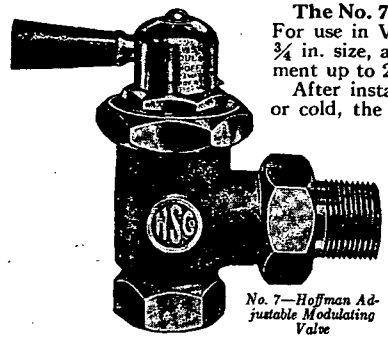
Prevents theft of No. 1 and No. 2 valves in public buildings, etc. No extra tapping is required as lock is easily applied when valve is inserted in radiator. By using set screws, valve is locked in position and can only be removed by a special key.



Hoffman Valve Lock

Write for Descriptive Circular—Locking the Door Against the Heat Thief

HOFFMAN "CONTROLLED HEAT" EQUIPMENT

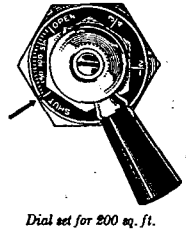


No. 7—Hoffman Adjustable Modulating Valve

The No. 7 Hoffman Adjustable Modulating Valve—For use in Vapor or Vapor Vacuum systems, is made in ¾ in. size, angle pattern only, having a range of adjustment up to 200 sq. ft. of direct cast-iron radiation.

After installation, whether the system is in operation or cold, the port of each valve is adjusted for the size of the radiator to which it is attached. Adjustment is simple; loosen a locknut; turn valve handle until proper number of graduations are visible on the dial plate; then tighten locknut. The valve handle may then be moved to admit sufficient steam to heat a quarter, half, three-quarter, or entire radiator. The valve stem stuffing box has a frictionless metallic fibre packing that will last indefinitely and require no attention, giving at the same time, a valve action so free that the pressure of only one finger is required to open the valve.

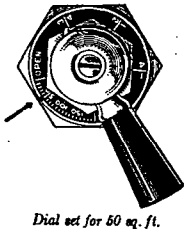
TOP DIAL PLATE ADJUSTMENT



Dial set for 200 sq. ft.



Port Area for 200 sq. ft. Radiator



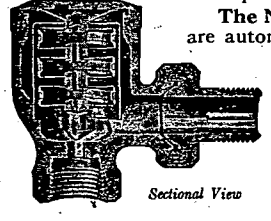
Dial set for 50 sq. ft.



Port Area for 50 sq. ft. Radiator

The visible adjustment aids the designing engineer by enabling heating contractor to make a final accurate adjustment which compensates for slight irregularities in pipe sizes, failure to ream pipe, installation of extra fittings not foreseen in original layout, etc. The advantages of an adjustable port in forced hot water systems to secure proper balance makes the **No. 7 Valve** especially adaptable for such use.

The No. 7 Valve is regularly supplied with lever handle. On special orders, it can be furnished with wood wheel, lock shield, closed top, extension stem and handle, or chain pull.



Sectional View

The Nos. 8 and 9 Hoffman Return Line Valves—These valves are automatic, non-adjustable, thermostatic and relieve all air and condensation without the loss of steam from radiators, pipe coils, indirect radiation, steam mains and risers, steam kettles, sterilizers and other devices where it is desired to get full efficiency and economy without waste of steam.

In service, they have established a reputation for efficiency and consistency of operation with the same degree of sensitiveness under either high or low pressure.

The body of the valve is made of cast steam metal; cap and tail piece are hot brass forgings; the thermostat of a special Hoffman alloy. In continued operation the thermostats will not break, stretch or lose their tension, giving long life and perfect operation.

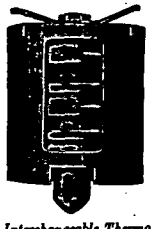
CHIEF FEATURES

The valve consistently operates under a pressure range from 13 in. of vacuum to 50 lb. steam pressure. Water at a temperature of approximately 12 deg. less than the temperature corresponding to the steam pressure causes full valve opening and free discharge of condensation.

Write for Descriptive Circular—Hoffman "Controlled Heat"

HOFFMAN "CONTROLLED HEAT" EQUIPMENT

Nos. 8 and 9 Hoffman Return Line Valves (continued)

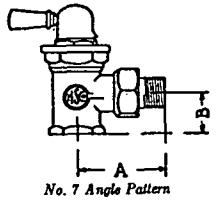


Interchangeable Thermo Member

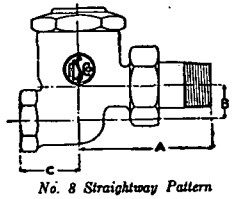
The thermostatic member is removable and may be changed from one valve to another of the same size without adjustment. This feature is appreciated by engineers who require the removal of the thermostat from the valves, until the system is thoroughly cleaned, and likewise by contractors complying with this practice.

The No. 8 Valve has ½ in. pipe connections, ¼ in. port and is furnished in Angle, Straightway, Right and Left-hand Offset Patterns. The normal capacity is 200 sq. ft. of cast iron radiation.

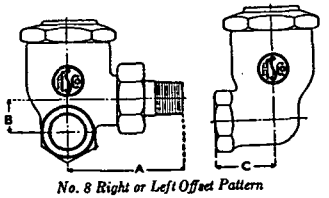
The No. 9 Valve with ¾ in. connection is made in Angle and Straightway Patterns only, and is suitable for 600 sq. ft. of cast iron radiation. For pressures up to 15 lb. valve has ⅜ in. port, for higher pressures $\frac{3}{16}$ in. port.



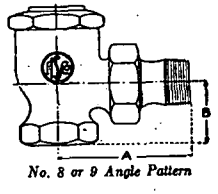
No. 7 Angle Pattern



No. 8 Straightway Pattern



No. 8 Right or Left Offset Pattern

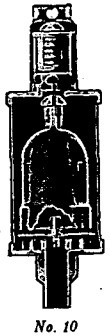


No. 8 or 9 Angle Pattern

Data and Dimensions

Style	Size In.	Diameter Valve Port In.	Maximum Capacity Sq. Ft.	Dimensions A	B	C
No. 7 Angle	¾	..	200	2⅞	1⅜	...
No. 17 Angle	¾	..	200	2¾†	1½	...
No. 8 Angle	½	¼	200	2²⁵⁄₃₂†	1⅝	...
No. 8 Straightway	½	¼	200	2²⁵⁄₃₂†	1⅝	1¹³⁄₃₂
No. 8 Offset	½	¼	200	2²⁵⁄₃₂†	1⅝	1⅝
No. 18 Angle	½	¼	100	2¾	1¼	...
No. 18 Straightway	½	¼	100	2¾	⅞	1⅜
No. 18 Offset	½	¼	100	2¾	⅞	1⅜
No. 9 Angle	¾	⅜*	600	3⅝	1¹¹⁄₃₂	...
No. 9 Straightway	¾	⅜*	600	3⅝	...	...

*No. 9 Valve furnished with ⅜ in. port for pressures above 15 lb.
†No. 8 Valves can be supplied where specified to meet standard roughing measurements of National Heating and Piping Contractors' Association.



No. 10

The No. 10 Hoffman Vapor Valve is used for venting the return mains in vapor systems or for other conditions where a large venting capacity is required. The vent port is ¾ in. in diameter.

Pipe connection, ¾ in. Maximum guaranteed operating pressure, 15 lb.

The No. 11 Hoffman Vapor Vacuum Valve is similar in construction and application to the No. 10 valve with the addition of a vacuum check on the vent port which prevents the return of air to the system through the vent port.

Pipe connection, ¾ in. Maximum guaranteed operating pressure, 15 lb.



No. 11

Write for Descriptive Circular—Hoffman "Controlled Heat"

HOFFMAN DIFFERENTIAL LOOP



Hoffman Differential Loop

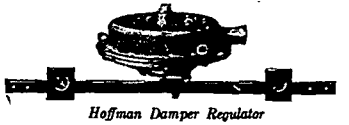
The Differential Loop is the safety device for maintaining a steady water line in vapor and vapor vacuum systems. It is entirely automatic, non-adjustable and has no moving parts to stick at a critical moment.

In operation the water rises in the return main **only** to a certain predetermined height. The loop then functions, blowing over a small quantity of steam which closes the No. 10 or 11 Valve used for venting the system and then compresses the air which is "bottled up" in the return main and builds up a pressure which prevents further rise of water in the vertical part of the return beyond the predetermined amount. As soon as this is accomplished, and the action is almost instantaneous, the loop reseals and no more steam is blown over until the differential pressure is lost. It will be readily seen that, by the alternate blowing over and resealing of the loop, a constant differential pressure will be maintained between the steam main and return main. Also by the maintenance of this differential no matter how high the boiler pressure goes, circulation will start in a radiator as soon as the inlet valve is opened even though the return main vent is closed through loop action.

Standard Differential Loops are made in four sizes, to handle systems up to 15,000 sq. ft. of radiation. For larger systems the No. 4 Loops can be installed in a battery.

No. 1 and No. 2 Loops should not be used where the low point in the dry return is less than 24 in. above boiler water line; with the No. 3 and No. 4 Loops this distance must be at least 30 in.

HOFFMAN DAMPER REGULATOR



Hoffman Damper Regulator

One of the most important features of the Hoffman Damper Regulator is the accurate control for only sufficient pressure is maintained to insure circulation to all radiators.

It is extremely sensitive in its action and controls so efficiently that when inlet valves are turned on or off, the fire is accelerated or retarded to meet the change in demand for vapor. A low constant pressure is always maintained so that vapor enters the radiator as soon as a valve is turned on.

The compensating or balancing plate is like a pair of scales. It is practically frictionless, remarkably sensitive and operates on slight changes in pressure.

It has an additional feature for the convenience of the installing fitter, in that the fulcrum on which the lever is suspended may be turned at different angles, permitting a straight chain connection with the dampers instead of at an angle, which might cause the dampers to bind.

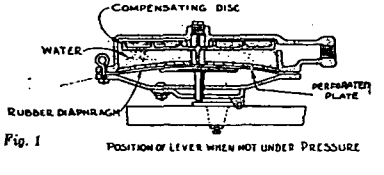


Fig. 1

Fig. 1 shows Damper Regulator under no pressure. Compensating plate is in its uppermost position, the bottom of the plate being in line with bottom of inlet. The space above diaphragm is filled with water up to the inlet. Weights on lever are to be so placed that they will hold the diaphragm against the perforated plate. Drafts are held open until the predetermined pressure is generated, when through diaphragm action which in turn is transmitted to the lever, drafts are closed.

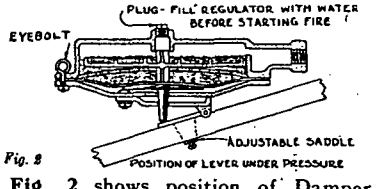
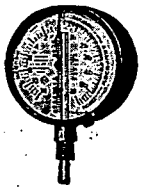


Fig. 2

Fig. 2 shows position of Damper Regulator when drafts are closed. Vapor pressure has overcome upward force exerted by the weights on lever arm and forced diaphragm downward. The water on the diaphragm lowers with it and likewise the compensating plate until top of the plate is level with the bottom of the inlet, thus preventing any addition to the water above the diaphragm. With a slight drop in vapor the weights force the diaphragm upward and drafts are opened.

Write for Descriptive Circular—Hoffman "Controlled Heat"

HOFFMAN THER-KOMPO-GAGE



Hoffman Ther-Kompo-Gage

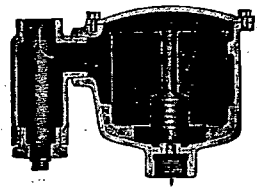
Measures pressure up to 30 lb., vacuum to 30 in., and temperature to 225 deg. Pressure is registered in ounces up to 5 lb. Vacuum is shown in half inches up to 10 in.

Temperature of steam or vapor being generated in the boiler is indicated on the thermometer.

Used in Hoffman "Controlled Heat" installations or in one-pipe gravity vacuum systems equipped with No. 2 valves; indicates efficiency of the apparatus when a warm house is maintained with vapor at temperatures considerably below 212 deg.

The No. 12 Hoffman Blast Trap is adapted for draining condensation from Indirect Radiators, Dryers, Drums, Blast Coils, Unit Heaters, Hot Water Generators and Ends of Long Steam Mains or Risers.

The Trap embodies the desirable feature of open bucket or float traps because it relieves condensation immediately upon its arrival at the trap regardless of the water temperature. Coupled with the float is a thermostatic member which positively overcomes the chief difficulty with float traps by automatically relieving air as well as condensation from the system.



No. 12 Hoffman Blast Trap

Table of Nominal Capacities, No. 12 Hoffman Blast Trap

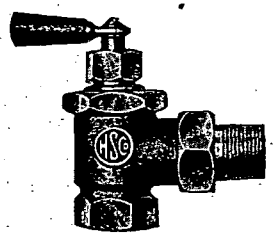
Pressure, Pounds per Square Inch	½	1	2	3	4	5
Capacity, Pounds per Hour	800	1000	1500	1800	2000	2500
*Capacity, Square Feet Radiation	3200	4000	6000	7200	8000	10000

Maximum Operating Pressure, 30 lb. Capacities for over 5 lb. pressure, furnished on application.

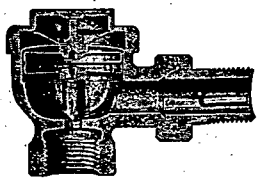
With Strainer: inlet connection, 1 in.; outlet, 1 in. Without Strainer: inlet connection, 1¼ in.; outlet, 1 in.

*On the basis of ¼ lb. of condensation per square foot per hour.

No. 19 Quick Opening Hoffman Radiator Valve is of the semi-packless type for vacuum pumps installations or for vapor systems where modulation is not required. Made in ¾ in. size only, capacity up to 200 sq. ft. C. I. Radiation. Regularly furnished in Lever Handle pattern. Wood Wheels or Lock Shields furnished on special order without extra charge. Extension stems supplied at an extra charge.



No. 19 Hoffman Radiator Valve

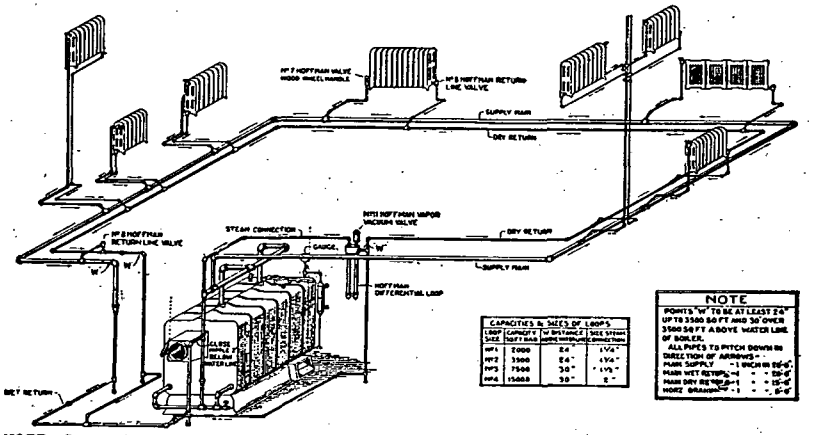


No. 18 Hoffman Radiator Trap

No. 18 Hoffman Return Line Valve or Radiator Trap is similar in principle to the No. 8 Valve. It is intended for pressures up to 15 lb. and radiators up to 100 sq. ft. Thermostats are interchangeable and made of special Hoffman Diaphragm Metal that will not soften, stretch or crack under repeated action. Made with ½ in. connections in Angle, Straightway, Right- and Left-hand Offset Patterns. For roughing measurements see page (758).

Write for Descriptive Circulars

TYPICAL INSTALLATION HOFFMAN "CONTROLLED HEAT" EQUIPMENT



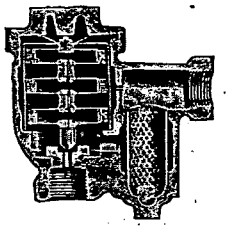
NOTE.—Loop discharges into high end of return main. This results in venting air from high point in return instead of low point

NOS. 20 AND 21 HOFFMAN THERMOSTATIC STEAM TRAPS

Pressure Range 0 to 100 lb. Without Change or Adjustment

The Hoffman Steam Trap Body is of strong, rugged all bronze construction. The diaphragms in the thermostat, the valve pins and valve seat are all made of the same non-corrosive alloy which has been successfully used for diaphragms in Hoffman Valves for a number of years. The alloy withstands high temperature steam, and repeated action without softening or cracking. It also withstands the scoring action of steam.

A strainer is built into the trap body permitting ready removal for cleaning. All renewable parts are interchangeable, permitting replacement without adjustment of any sort. The trap is built to give maximum service with minimum attention and when repairs or cleaning are required the work can be quickly done.



Nos. 20 and 21 Hoffman Thermostatic Steam Trap

The Hoffman Steam Trap normally has a wide open vent port which is maintained until all air and condensation is relieved from the system, after which steam contact with the thermostat closes the port. No hand operated by-passes are required to vent air from the system. The trap cannot air-bind or freeze.

The discharge capacity is dependent upon differences between the temperature of condensation delivered to the trap and steam temperature, the greater the difference the larger the capacity of the trap. The following tables give continuous discharge capacities.

	NO. 20 TRAP—Pressure						NO. 21 TRAP—Pressure					
	10	30	50	70	90	100	10	30	50	70	90	100
Temperature Drop 20°	275	550	715	820	900	925	375	725	925	1085	1190	1225
Temperature Drop 35°	725	1075	1380	1675	1830	1860	950	1410	1860	2250	2490	2550

No. 20 Trap has ½ in. pipe connections, ⅝ in. port. Weight 3¼ lb.
No. 21 Trap has ¾ in. pipe connections, ¼ in. port. Weight 3¾ lb.

Write for Descriptive Circulars

Illinois Engineering Company

General Offices and Factory: CHICAGO

Branches and Representatives

Akron		Indianapolis	Montreal	Pittsburgh	Scranton
Baltimore		Kansas City	New Orleans	Portland	Seattle
Birmingham	Dayton	Little Rock	New York City	Providence	Shreveport
Boston	Denver	Los Angeles	Oklahoma City	Richmond (Va.)	South Bend
Buffalo	Detroit	Memphis	Omaha	Rochester	Spokane
Cincinnati	Grand Rapids	Milwaukee	Peoria	St. Louis	Toledo
Cleveland	Halifax	Minneapolis	Philadelphia	San Francisco	Toronto
Columbus	Harrisburg				Wichita Falls
Dallas	Houston				Youngstown

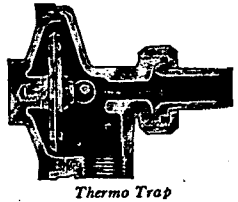
PRODUCTS—Illinois Heating Systems—Eclipse Steam Specialties

Illinois Heating Systems

Successfully installed in thousands of buildings—the result of over 25 years of special work in this line, and the ultimate in efficiency and economy.

Illinois Thermo Trap

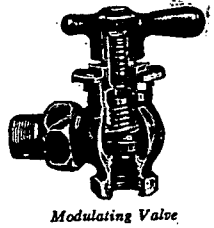
The original vertical seat trap. Dirt does not lie on seat—self cleaning, non-adjustable, positive in operation; durable, will stand 50 lb. steam pressure which shows the great strength of the diaphragm, which is the reason for the long life and durability of these Traps. Thousands in operation for over 15 years without diaphragm replacements.



Thermo Trap

Illinois Modulating Supply Valve

Quick Opening—only a half turn of handle from open to closed position. Packless, Bakelite handle, steam tight on 50 lbs. pressure. Large diameter of thread spool and machine cut threads make valve easy of operation.



Modulating Valve

The improved Bakelite handle insulates the hand from heat.

The graduated dial shows the open or closed or any position of the valve.

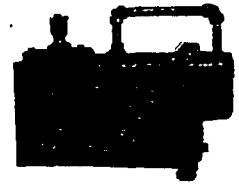
Furnished with Lock Shield and Key, or with Bakelite Wheel handle, upon order.

Illinois Vapor Systems

Illinois Vapor Systems are capable of operating automatically on any pressures possible in a low pressure heating system—from 10 lb. to 20 in. of vacuum. Our improved equipment actually insures operation under vapor—less than atmospheric pressure—with only two or three firing periods per 24 hrs. The advantages are healthful, modulated heat, and a *fuel saving of 25-30 per cent* over other systems of heating. This result is secured by the ILLINOIS HEAT RETAINOR—Browne Patent, a device which marks an epoch in the heating art.

Illinois Heat Retainor

This improved device not only vents air from the System on ⅛ oz. pressure, but it absolutely prevents air pulling back into the System, thus allowing the System to remain under vacuum for hours at a time.



Illinois Heat Retainor

No dirt or scale can reach the valve of the Retainor, and even the air passing through same is washed, so this device will remain in operative condition over long periods.

Our Bulletin No. 22, describes the operation in detail—Copy sent upon request.

Illinois Return Trap or Alternating Receiver

This device automatically puts the water back in the boiler against any boiler pressure possible in a low pressure heating system.



Illinois Return Trap

The float trips the weights which in turn positively operate the valves. The operation is forceful and positive and this mechanism cannot be caught on dead centre by water half filling the tank. No external parts to be adjusted or tampered with. No stuffing boxes—all working parts enclosed in the tank.

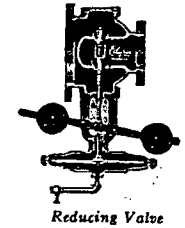
Our Sales-Engineering Organization will be glad to give detailed technical information regarding our products and to advise as to their proper installation.

ILLINOIS PRODUCTS—Eclipse Steam Specialties

Eclipse Steam Specialties

The old John Davis Co. Eclipse Steam Specialties have been on the market for over 40 years, and embody the improvements and refinements suggested by this long period of service. These Specialties are quality products, having bronze and monel metal pistons, seat rings and valve parts, the bodies are extra heavy, and every piece of apparatus is carefully steam tested—under working pressure where same is given—before shipment.

Pressure Reducing Valves, for all pressures and services.
Back Pressure, and *Atmospheric Relief Valves.*
Separators, Oil and *Steam, Cast Iron* and *Steel.*
Steam Traps, all pressures.
Non-Return or *Stop* and *Check Valves.*
Pump Governors, Balanced Valves.
Float Valves, Expansion Joints, Pipe Strainers.



Reducing Valve

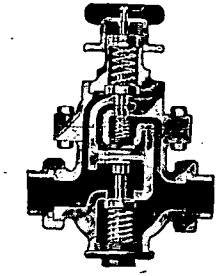
Reducing Valves. In general use on Vacuum or low pressure Heating Systems. Will reduce to 4 oz. pressure from even 150 lb. initial pressure.

The large diaphragm insures sensitive operation.

Made in both straight-way and expanded outlet bodies.

Sizes ¾ in. to 12 in.

Eclipse Master Reducing Valve

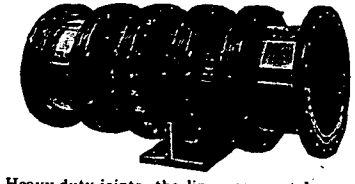


A pilot type valve will reduce from any pressure up to 250 lb. down to 10 lb. and hold reduced pressure constant at all times—even against a "dead end" pipe.

Made of Bronze with monel valves and trimmings.

Sizes ½ in. to 6 in.

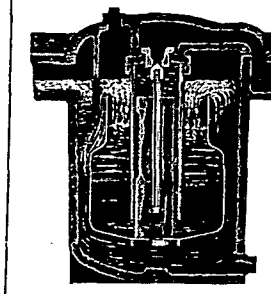
Illinois Expansion Joints - Single and Double Traverse



Heavy duty joints, the liners are cast bronze—not brass tubing. The bolts are through bolts, no stud bolts used.

Tapped for service connections in anchor section if desired.

Eclipse Steam Trap



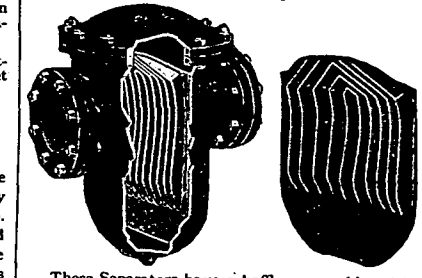
Something new in Steam trap design. The valve and stem are separate from the bucket and only operated by the bucket at its extreme top and bottom travel —*Result*—

Valve is always either full open or tight closed.

No wire drawing or cutting of valve and seat, which are of Monel metal. Steam tight and long lasting.

Bulletin No. 33 describes in detail.

Horizontal Oil Separator

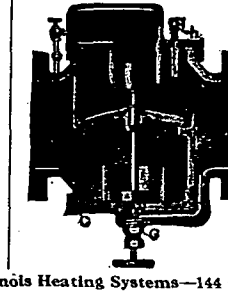


These Separators have a baffle removable without disturbing the piping. Occasional cleaning is necessary for proper elimination of oil.

The port areas are over 3 times the diameter of the pipe area, hence these separators are effective.

Eclipse Back Pressure and Combination Relief Valves

Made in Vertical and Horizontal types, straight-way or angle pattern, for condensing and non-condensing engines.



It is noiseless and works equally well on pressure or vacuum, air cushioned by back pressure in dashpot. Constructed entirely of metal with no springs; wearing parts of special bronze.

Size 4 in. to 36 in.

Catalog and Bulletins—Illinois Heating Systems—144 pages

BULLETINS

No. 14—Heating Specialties.
No. 22—Vapor System Details.
No. 45—Non-Return Valves.
No. 103—Pressure Reducing Valves.
No. 203—Back Pressure, and Relief Valves, Exhaust Heads.
No. 33—Steam Traps.
No. 53—Separators—Oil and Steam.
No. 203—Float and Balanced Valves.

William S. Haines & Company

12th and Buttonwood Sts., **Philadelphia, Pa.**

Manufacturers of Equipment for Vapor and Vacuum Heating Systems

Haines Vento Thermostatic Trap.

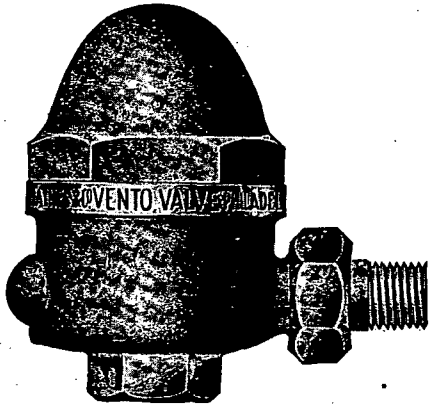
Haines Medium Pressure Thermostatic Trap.

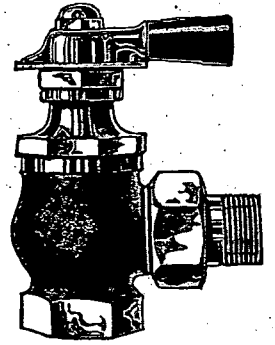
Haines High Pressure Thermostatic Trap.

Haines Float and Thermostatic Blast Trap.

Haines Vent Trap.

Haines Modulating Valve.





HAINES traps pass all of the air and the water of condensation without permitting the escape of steam.

The HAINES trap is operated by a spring tempered bourdon tube in which a volatile liquid is hermetically sealed. The thermostatic member is mounted outboard the valve seat closing the valve piece against the flow of steam. A variation of 1 deg. fahr. is sufficient to open or close the valve. Due to the horizontal seat and the placing of the thermostat in the return line HAINES traps do not become inoperative from scale, or other foreign matter and they cannot freeze.

HAINES thermostatic traps are made in sizes from ½ to 1½ in.

Every trap is factory tested and adjusted before shipment.

They are suitable for pressures from below atmosphere to 100 lb. per square inch.

HAINES modulating valves never need repacking. They seat tightly and open on less than a full turn of the lever or wheel handle.

Made in sizes from ½ to 2 in. in angle, globe, or corner pattern.

HAINES VENTO TRAPS

No. of Trap	Center to Inlet	Center to Outlet	Capacity Sq. Ft.
1	2⅞"	1⅛"	125
2	3⅛"	1⅜"	200
2E	3⅜"	1⅜"	250
3	3⅝"	1⅝"	400
3E	3⅞"	1⅝"	500

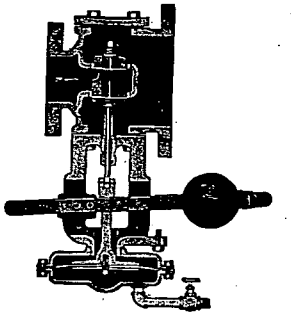
HAINES MODULATING VALVES

Size of Valve	Center to Inlet	Center to Outlet
½"	1⅞"	2½"
¾"	1½"	2⅝"
1"	1⅝"	3"
1¼"	1⅝"	3⅛"
1½"	2⅛"	4¼"
2"	2⅝"	4⅝"

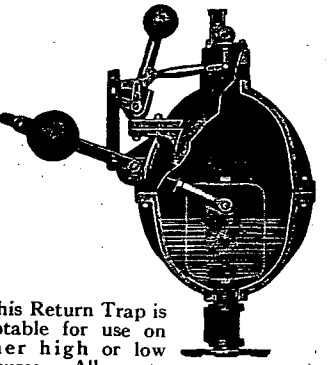
Kieley & Mueller, Inc.

Manufacturers of Specialties for Steam, Water, Air, Oil and Gas

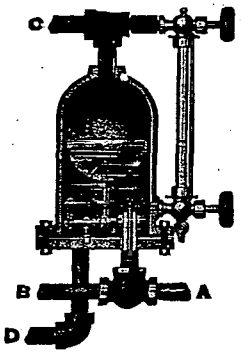
34 West 13th Street **Agents in all Principal Cities** **New York City**



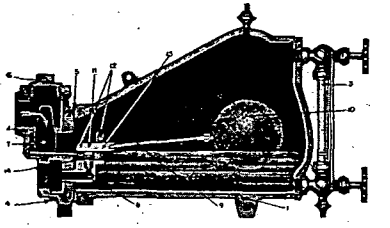
The Kieley Special 98 Reducing Valve is suitable for regulating steam pressure for Vapor and Vacuum Heating. This valve will reduce 100 lb. pressure to a vapor.



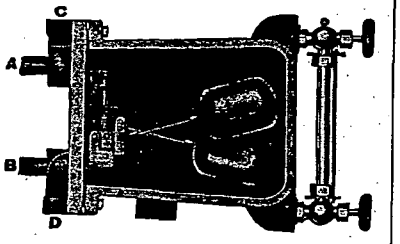
This Return Trap is adaptable for use on either high or low pressures. All parts subject to wear are located externally and easily removable.



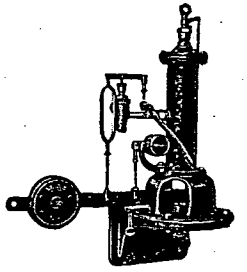
The Rapid Feeder is designed for use in controlling the water supply to heating and industrial boilers. It is a "direct to boiler" feeder and therefore, has extraordinary high capacity.



Kieley Ball Float Traps have all the desirable features necessary for taking care of High and Low Pressure Condensation. They are compact, easily repaired and have high condensation capacities.



The Duplex Feeder feeds water to the boiler when required and discharges excess water if sluggish returns tend to flood or cause a high water line.



The Climax Junior Damper Regulator. This is a Hydraulic Damper Regulator designed for large heating systems.

TRADE MARK KELLY

Complete Satisfaction

Kelly Brass Works

226-232 West Ontario Street

Chicago, Ill.

TRADE MARK KELLY

Scientific Construction

"KELLY" Valves are made especially for steam-heating service and have many features which recommend their use by the engineer, architect and heating contractor.

The interior construction of "KELLY" Air Valves are identical. The float in the sectional view is sealed with a phosphor bronze diaphragm at the bottom. A definite amount of volatile liquid is placed in the float before sealing which vaporizes from the heat of the steam causing the diaphragm to expand and raise the float thereby closing the escape port in the top of the valve.

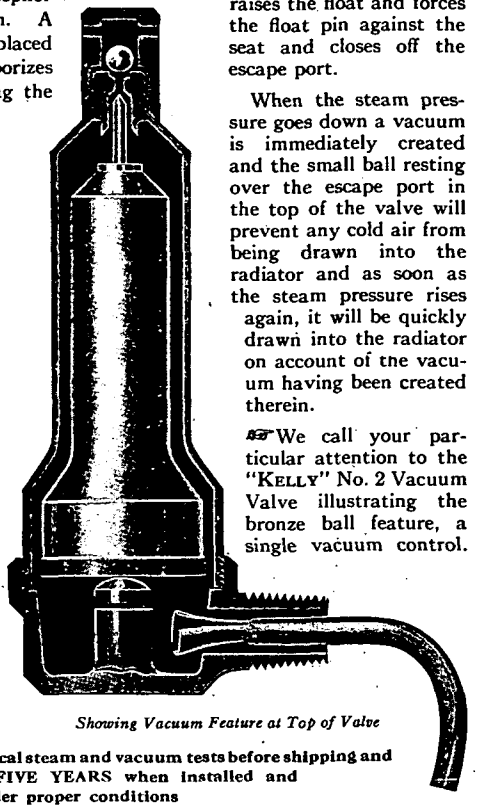
All "KELLY" valves are so constructed that no adjustment is required and, no one can possibly tamper with them. They will operate under all pressures up to 10 lb., venting the radiator of the accumulated air and closing against steam and water. Any water of condensation in the valve will be drained back to the radiator through the syphon tube.

The outer shell of the valve is threaded into a drop forged brass base and the valves are substantially constructed of the best grade of materials.

The sectional view shows the vacuum feature at the top of the valve. The small bronze ball is loosely encased at the top, resting over the escape port in the top of the valve. When the steam is turned on in the radiator the slightest pressure will raise the ball permitting the escape of all the air until the steam begins to enter the valve causing the volatile liquid in the float to expand the diaphragm which raises the float and forces the float pin against the seat and closes off the escape port.

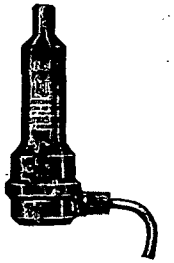
When the steam pressure goes down a vacuum is immediately created and the small ball resting over the escape port in the top of the valve will prevent any cold air from being drawn into the radiator and as soon as the steam pressure rises again, it will be quickly drawn into the radiator on account of the vacuum having been created therein.

☞We call your particular attention to the "KELLY" No. 2 Vacuum Valve illustrating the bronze ball feature, a single vacuum control.



Showing Vacuum Feature at Top of Valve

"KELLY" Valves are subjected to practical steam and vacuum tests before shipping and are GUARANTEED FOR FIVE YEARS when installed and operated under proper conditions



No. 1

⅛ in. Side-Outlet Air Valve for Radiators



No. 3

¼ in. Bottom-Outlet Air Valve for Mains, Coils and Risers



No. 5

⅜ in. Bottom-Outlet Quick Vent Air Valve for Mains and HV Stacks

NOTE.—Contains Float—will close against water.

Kelly Brass Works

226-232 W. Ontario Street, Chicago, Illinois

All cuts one-third size

The complete line of KELLY Non-Adjustable Automatic Steam, Air and Vacuum Valves are manufactured complete by the Kelly Brass Works.

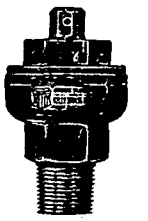
KELLY valves are made to give entire satisfaction and are the result of over 35 years experience.

KELLY valves are subjected to practical steam and vacuum tests before shipping and are guaranteed for five years when installed and operated under proper conditions.

Complete Satisfaction

TRADE MARK KELLY

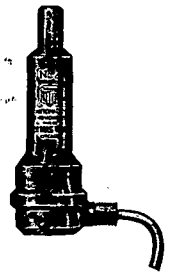
Scientific Construction



No. 7

¾ in. Bottom-Outlet Quick Vent Air Valve for Mains and HV Stacks

NOTE.—Will not close against water.



No. 2—Vacuum

⅛ in. Side-Outlet Air Valve for Radiators



No. 4—Vacuum

¼ in. Bottom-Outlet Air Valve for Mains, Coils and Risers



No. 6—Vacuum

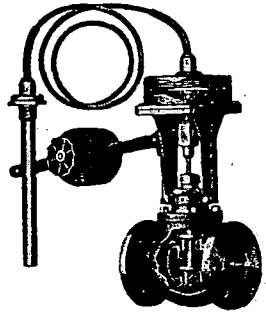
⅜ in. Bottom-Outlet Quick Vent Air Valve for Mains and HV Stacks

NOTE.—Contains Float—will close against water.

Klipfel Manufacturing Co.

2641-2659 West Harrison Street :-: Chicago, Ill.

Manufacturers of Automatic Valve Specialties

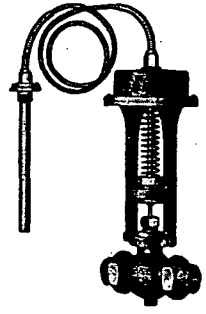


No. 48 Vapor Thermostat, Lever Type

Sizes: ½ to 8 in., inclusive. Bronze bodies in sizes 1½ in. and under, union connections only. Iron bodies in sizes 2 in. and above, flanged ends only.

No. 48 Vapor Thermostats.—Automatically maintain hot water in steam heated tanks at any desired temperature between 140° and 180°; but can be made special for other temperatures. A complete operating unit within itself—it is self-contained. No compressed air, water, electrical, or other auxiliary power required. Lever of lever type is fitted with roller bearings to insure frictionless operation.

The sensitive all-metal bellows will move the inner valve farther on a given temperature-pressure change than any competing bellows of the same diameter and length.



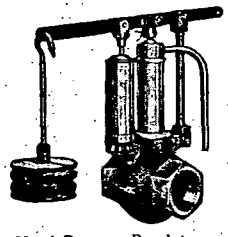
No. 49 Vapor Thermostat, Spring Type

Sizes: ½ to 2½ in., inclusive. Bronze bodies in sizes 1½ in. and under, union connections only. Iron bodies in sizes 2 in. and above, flanged ends only.

No. 49 Vapor Thermostats.—Similar to the No. 48 Vapor Thermostat, except that a spring is used instead of a lever and weight. The spring type may be used where space does not permit the use of the lever type and where extreme sensitiveness and a wide range of temperature adjustment are not required. The semi-balanced, bevel seated, bronze inner valve is normally held open by a spring. An increase of temperature of a volatile fluid hermetically sealed within the temperature sensitive bulb, which is installed in contact with the medium, causes the bellows to expand and operate the inner valve.

No. 1 Pressure Regulators.—Automatically reduce any initial steam, air or water pressure to any desired reduced pressure down to 2 lb. and maintain reduced pressure constantly regardless of fluctuations in initial pressure, or changes in the demand for steam. When specified for the control of air or water, the piston is provided with special leather cup packing.

Can be furnished with expanded outlet in sizes 1x2 to 12x24 in., inclusive.

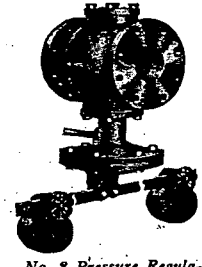


No. 1 Pressure Regulator, Piston Type

Sizes: ⅜ to 14 in., inclusive. Bronze bodies in sizes 1½ in. and under, screwed ends only. Iron bodies in sizes 2 in. and above; 2 to 6 in., inclusive, screwed or flanged ends, but screwed ends will be furnished unless otherwise specified; sizes 7 in. and above, flanged ends, only.

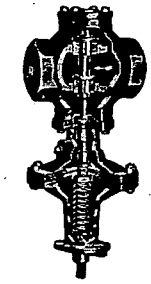
No. 3 Pressure Regulators.—Automatically reduce any initial steam pressure to any desired reduced pressure, either below atmosphere or up to 5 lb. above atmosphere, and constantly maintain reduced pressure regardless of initial pressure fluctuations or changes in the demand for steam. Includes no packing box, thus eliminating leakage and friction on valve stem. Inner valves and seats are bronze, bevel seated.

Can be furnished with expanded outlet.



No. 3 Pressure Regulator, Diaphragm Type

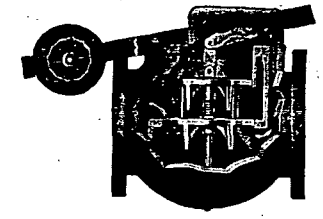
Sizes: ⅜ to 14 in., inclusive. Bronze bodies in sizes 1½ in. and under, screwed ends only. Iron bodies in sizes 2 in. and above; 2 to 6 in., inclusive, screwed or flanged ends, but screwed ends will be furnished unless otherwise specified; sizes 7 in. and above, flanged ends, only.



No. 33 Pressure Regulator, Spring Type

No. 33 Pressure Regulators.—Similar to the No. 3 Pressure Regulator, except that a spring is used instead of a lever and weight. Being equipped with a locking device, they are particularly suited for use under conditions where the adjustment of a lever and weight type might be tampered with. Will reduce any initial steam, air or water pressure to any desired reduced pressure not exceeding 50 lb.

Cannot be used to maintain pressures below atmosphere. Expanded outlet can be furnished.



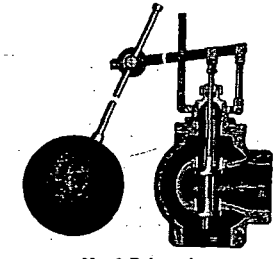
No. 28 Noiseless Back Pressure Valve

Sizes: 2 to 24 in., inclusive. All sizes made with iron bodies and with flanged ends; sizes 2 to 8 in., inclusive, also made with screwed ends. Unless otherwise specified, sizes 6 in. and under will be shipped screwed ends; sizes 8 in. and above with flanged ends.

Sizes: ¼ to 6 in., inclusive. Bronze bodies in sizes 1½ in. and under, screwed ends only. Iron bodies in sizes 2 in. and above; sizes 2 to 6 in., inclusive, are made with screwed or flanged ends, but screwed ends will be furnished unless otherwise specified.

No. 28 Noiseless Back Pressure Valves.—Automatically and noiselessly maintain any desired back pressure on exhausts of non-condensing engines. Because of the patented construction, inner valve is effectively stabilized and can not pulsate in unison with the stroke of the engine. Operated in either horizontal or vertical position. Preferable installation is in horizontal pipe line. Iron bodies, bronze inner valves and trimmings.

No. 6 Balanced Float Valves.—Automatically control the supply of cold water to open tanks, so as to maintain a practically constant water level. The inner valve consists of two perfectly balanced bronze plunger discs, and is unaffected by the water pressure. Can be furnished with bevel seated valves at an extra price. Angle and globe patterns, with seamless copper float, for working pressures up to 200 lb. Swivel guide yoke can be turned to any position.

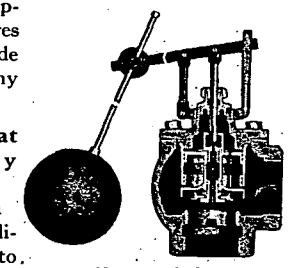


No. 6 Balanced Float Valve

Sizes: ⅜ to 20 in., inclusive. Bronze bodies in sizes 1½ in. and under, screwed ends only. Iron bodies in sizes 2 in. and above; 2 to 6 in., inclusive, screwed or flanged ends, but screwed ends will be shipped unless specified otherwise; sizes 7 in. and above, flanged ends, only. All sizes 14 in. and under made angle or globe patterns, but angle pattern will be shipped unless specified globe. Sizes 16 in. and above made globe patterns, only.

No. 7 Single Seated Float Valves.—Automatically maintain a constant level of hot or cold water in open tanks. Single seated, auxiliary operated. Seat equal to pipe size. Swivel guide yoke allows the float to be turned to any position. Includes a packing box with gland to prevent leakage past the valve stem.

Angle and globe patterns, with seamless copper float, for working pressures up to 200 lb.



No. 7 Single Seated Float Valve

Sizes: ¼ to 12 in., inclusive. Bronze bodies in sizes 1½ in. and under, screwed ends only. Iron bodies in sizes 2 in. and above; 2 to 6 in., inclusive, screwed or flanged ends, but screwed ends will be shipped unless specified otherwise; size 8 in., flanged ends only. Sizes 8 in. and under made angle or globe patterns, but angle pattern will be shipped unless specified globe. Sizes 10 and 12 in. made to order, flanged ends, globe pattern only.

Marine-Galligan Co., Inc.

14 So. 20th Street

Philadelphia :-: Penna.

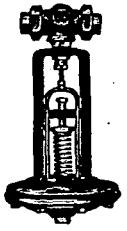
Number	M-G PRODUCT
1	⅛ Inch Siphon Air Valve.
2	⅛ Inch Siphon Air and Vacuum Valve.
3	¼ Inch Quick Vent Float Air Valve.
4	⅛ x ¼ Inch Air Line Valve.
5	¾ Inch Vapor Vent Valve.
6	¾ Inch Vapor Vacuum Vent Valve.
7	½ Inch Lever Handle Modulating Radiator Valve.
27	¾ Inch Lever Handle Modulating Radiator Valve.
37	1 Inch Lever Handle Modulating Radiator Valve.
47	1¼ Inch Lever Handle Modulating Radiator Valve.
8	½ Inch Round Handle Packless Radiator Valve.
28	¾ Inch Round Handle Packless Radiator Valve.
38	1 Inch Round Handle Packless Radiator Valve.
48	1¼ Inch Round Handle Packless Radiator Valve.
58	1½ Inch Round Handle Packless Radiator Valve.
68	2 Inch Round Handle Packless Radiator Valve.
9	½ Inch Packless Radiator Gate Valve.
29	¾ Inch Packless Radiator Gate Valve.
39	1 Inch Packless Radiator Gate Valve.
49	1¼ Inch Packless Radiator Gate Valve.
59	1½ Inch Packless Radiator Gate Valve.
10	½ Inch Lock and Shield Packless Valve.
210	¾ Inch Lock and Shield Packless Valve.
310	1 Inch Lock and Shield Packless Valve.
410	1¼ Inch Lock and Shield Packless Valve.
510	1½ Inch Lock and Shield Packless Valve.
610	2 Inch Lock and Shield Packless Valve.
11	½ Inch Thermo Radiator Trap.
12	½ Inch Thermo Radiator Trap.
212	¾ Inch Thermo Radiator Trap.
14	¾ Inch Thermo Drip Trap.
15	¾ Inch Float and Thermo Drip Trap.
215	1 Inch Float and Thermo Drip Trap.
315	1¼ Inch Float and Thermo Drip Trap.
415	1½ Inch Float and Thermo Drip Trap.
515	2 Inch Float and Thermo Drip Trap.
16	5 Inch Diameter Retard Compound Gauge.
216	8 Inch Diameter Retard Compound Gauge.
17	10 Inch Vapor Damper Regulator.
18	1000 Square Feet Capacity Alternator.
218	3000 Square Feet Capacity Alternator.
318	6000 Square Feet Capacity Alternator.
19	1800 Square Feet Capacity Direct Return Trap.
219	3600 Square Feet Capacity Direct Return Trap.
319	6000 Square Feet Capacity Direct Return Trap.
419	9000 Square Feet Capacity Direct Return Trap.
20	Duplex Water Feeders.
101	M-G Boiler Cleaning Compound per pound
102	M-G Boiler Mending Liquid per quart

Mason Regulator Company

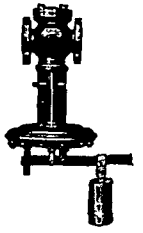
Boston, Mass.

San Francisco, Calif. Montreal, Canada

Manufacturers of
Pressure Regulators and Steam Specialites

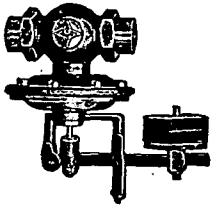


No. 223, Spring Type
Sizes ½"-1½"



No. 21, Lever Type
Sizes 8"-16"

PRESSURE REDUCING VALVES FOR HEATING SYSTEMS

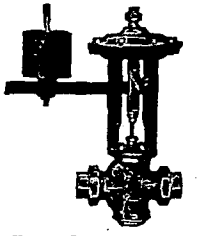


Vacuum Regulating Valve
Sizes ½"-4"

For regulating the amount of vacuum on separate branches of a main vacuum system.

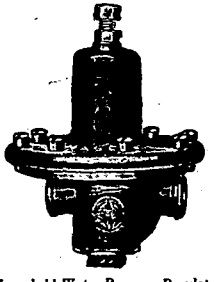
The new **Mason** Reducing Valves for heating systems have attained the same popularity as the well known **Mason** high pressure reducing valves so widely used industrially.

These valves are up to the **Mason** standard of quality but are exceedingly moderate in price. For economy as well as lasting satisfaction it is very much to your advantage to specify **Mason.**



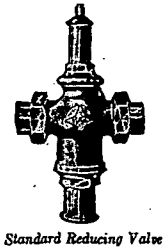
Vacuum Pump Regulators
Sizes ½"-4"

For regulating the supply of steam to the requirements of a steam driven vacuum pump and thereby automatically maintaining a uniform vacuum on the system.



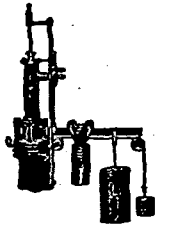
Household Water Pressure Regulator
Sizes ½"-1"

Designed for domestic service where the city water pressure is too great for economical house use. Eliminates noise in bathroom fixtures, leaking faucets and splashing in bowls and tube.



Standard Reducing Valve
Sizes ½"-8"

For High Pressure Service.



Damper Regulator

Made in various sizes for handling damper equipment on both high and low pressure boilers, operating on forced, induced, or natural draft.

CATALOG—Write for Pocket Catalog and Handbook No. 62. It contains complete description and prices of these and other **Mason** Regulators.

Jas. P. Marsh & Company

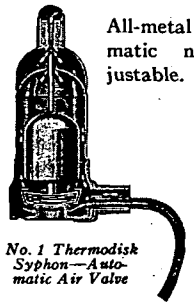
Established 1865

114-124 S. Clinton St. - CHICAGO, ILL.

SALES AGENCIES IN MOST PRINCIPAL CITIES

Thermodisk

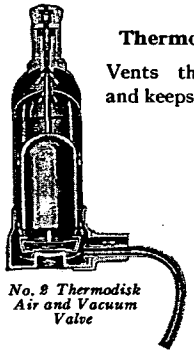
All-metal Automatic non-adjustable.



No. 1 Thermodisk Syphon—Automatic Air Valve

Thermodisk

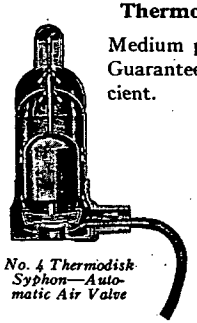
Vents the air and keeps it out.



No. 2 Thermodisk Air and Vacuum Valve

Thermodisk

Medium priced. Guaranteed efficient.



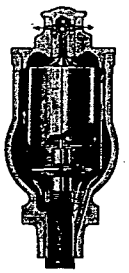
No. 4 Thermodisk Syphon—Automatic Air Valve



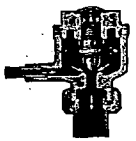
No. 7 Thermodisk Air Eliminator

Free and unlimited vent of all air, hot or cold, cannot water-log, do not spit or leak water, and close instantly for steam or vapor.

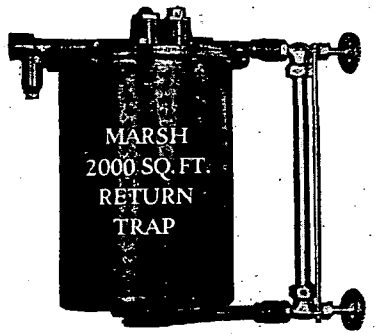
Sizes and capacities for every requirement.



No. 6 Thermodisk Rapid Vent

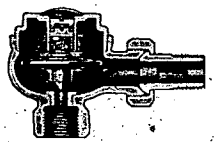


No. 3 Thermodisk Air Line Valve



Marsh 2000 Sq. Ft. Boiler Return Trap for returning water of condensation to Boiler. Also furnished in larger sizes

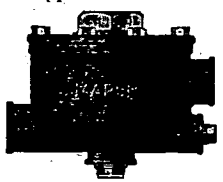
Marsh Reflux Traps for installation on return of radiators of any two-pipe return steam heating system. Also for pipe coils in Refining, Cooking and Drying apparatus.



No. 1 Reflux Trap

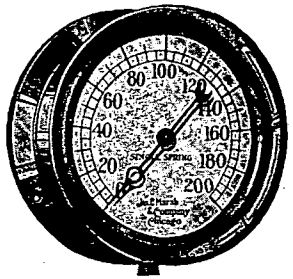


No. 2 Reflux Trap

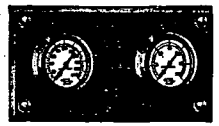


No. 4 Reflux Cast Iron Body Thermostatic Drip Trap

Marsh Indicating Gauge



Marsh Gauge Board

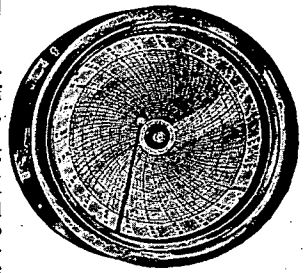


Marsh Gauges for every requirement of indicating Pressure, Vacuum, Altitude, etc.

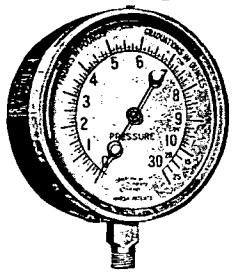
Marsh Recording Gauges where a high grade, accurate instrument is required and where it is desired to match other instruments on Gauge Boards, etc.

We specialize in Gauge Board outfits complete with all instruments.

Marsh Recording Gauge



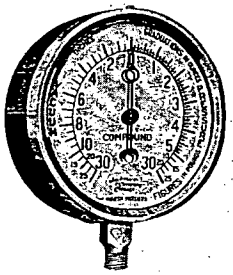
Low Pressure Ounce Gauge



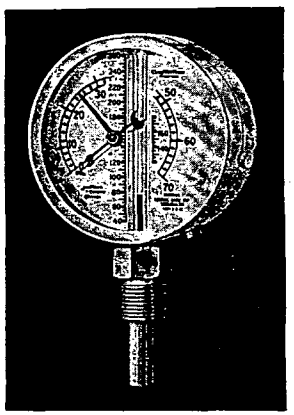
Show exact pressure in ounces and pounds.

A necessity for the intelligent, economical and proper operation of "Vapor," "Vacuum," "Semi-Vacuum," and "Atmospheric" Heating Systems and for any low pressure boiler.

Compound Ounce Gauge

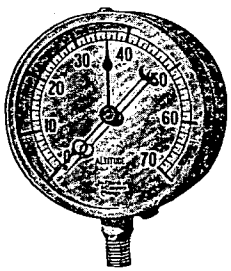


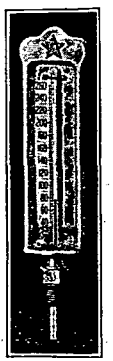
Marsh Ther-Alti-Meter



Combined Altitude Gauge and Hot Water Thermometer. The two indications, altitude and temperature, at a glance. The ideal and logical instrument to specify for any hot water heating boiler.

Marsh Altitude Gauge and Hot Water Thermometer





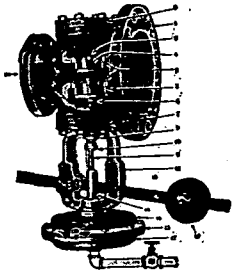
For any hot water heating boiler where the separate Altitude Gauge and Hot Water Thermometer are preferred.

Architects and Heating Engineers will find illustrated and described a Marsh Gauge, Radiator or Steam Trap, Automatic Air Valve, Vent and Heating Specialty for each service requirement—in literature which we will be pleased to send upon request.

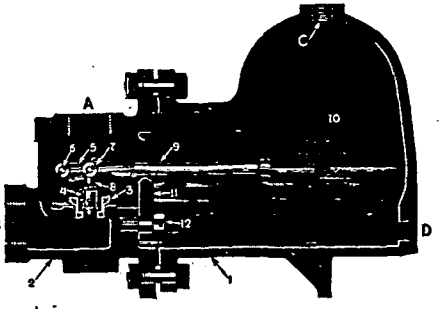
The McAlear Mfg. Co.

1901-1907 So. Western Avenue **CHICAGO**

Power and Heating Specialties for Controlling Pressures and Flow of Steam, Water, Air or Gas

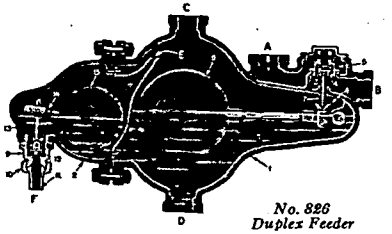


No. 155



No. 155 McALEAR Reducing Valves are constructed in either the diaphragm weight and lever type, spring weighted diaphragm type or the pilot operated type. They are made with either single or double seats, and with expanded outlets when desired, depending on the type selected. They will reduce steam pressure from 5 to 250 lb. to any desired service pressure from a partial vacuum to 240 lb. Complete information furnished on application.

Sizes ⅜ to 20 in.



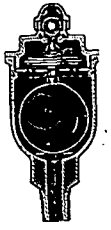
No. 826 Duplex Feeder

McALEAR Direct-to-Boiler Water Feeders are made both Simplex and Duplex and are equipped with Mercoid Switches, when desired, for Oil Burner Control. Working parts of non-corrosive material, heavy seamless floats and they feed water direct to the boiler. Complete information in Bulletin "K-1."

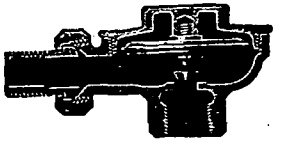
McALEAR traps are built in both Open Bucket and Ball Float types and are constructed in several different styles to meet any service condition.

No. 717 (illustrated) is invaluable for low pressure drip connections but can be used on pressures up to 125 lb. It has large capacity, equipped with accessible valve construction, deep water seal, and thermostatic element when used for blast trap duty.

Sizes ½ to 3 in.



No. 15 Automatic Air Valve is used for relieving mains and risers of low pressure, vapor and gravity heating systems, vento coils, and indirect radiators of air. It will operate at any pressure up to 15 lb., and is made in sizes ⅜, ½, ¾ and 1 in. sizes.



McALEAR Radiator Traps are constructed in several different styles and sizes and patterns either plain or nickel-plated. The thermostatic elements are made of the best quality bronze metal, and are suitable for withstanding any temperature or pressure from a partial vacuum to 15 lb.

The McAlear line of Power, Heating, Gas and Oil Specialties also includes: Radiator Hangers, Packless Radiator Valves, Return Traps, Grease Extractors, Dirt Strainers, Pump Governors, Damper Regulators, Back Pressure Valves, Water Regulating Valves, Tank Controllers, Gas Regulating Valves, Liquid Level Controllers and many other devices. General Catalogue No. 28 illustrating our complete line, will be gladly furnished upon request.

Milwaukee Valve Company

"MILVACO" Heating Specialties

Burrell and Chase Streets **Milwaukee, Wis.**

Representatives in all Principal Cities

NEW YORK, N.Y.	NEWARK, N.J.	LOUISVILLE, KY.	ATLANTA, GA.	PHOENIX, ARIZ.
WASHINGTON, D.C.	SEATTLE, WASH.	CINCINNATI, OHIO	DULUTH, MINN.	SAN FRANCISCO, CALIF.
SPOKANE, WASH.	PORTLAND, ORE.	DAYTON, OHIO	KANSAS CITY, MO.	RICHMOND, VA.
READING, PA.	MINNEAPOLIS, MINN.	COLUMBUS, OHIO	BALTIMORE, MD.	BOSTON, MASS.
LOS ANGELES, CALIF.	DETROIT, MICH.	DENVER, COLO.	FORT WORTH, TEXAS	DALLAS, TEXAS
PITTSBURGH, PA.	CLEVELAND, OHIO	ST. LOUIS, MO.	OMAHA, NEBR.	PHILADELPHIA, PA.
CHICAGO, ILL.	WINNIPEG, CANADA	INDIANAPOLIS, IND.	TOLEDO, OHIO	JACKSON, MISS.

Packless Valves

NOTE.—In addition to types illustrated, Dole-Milwaukee Packless Valves can be furnished in the following patterns:
Lock and Shield Angle.
Lock and Shield Graduate.
Union Gate.
Union Globe and Right and Left Hand Corner.
Always specify steam or water.
Send for Bulletin No. 24

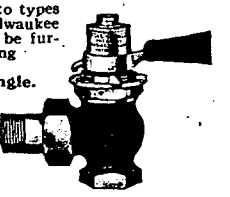


Fig. 209-M Lever Handle Graduate

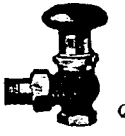


Fig. 215-M Quick Opening Angle

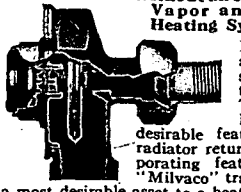
Fig. 210-M Knob Handle Graduate



All patterns made in sizes ½ to 2 in. inclusive.

Thermostatic Trap

Without an equal for Vacuum, Vapor and Modulating Heating Systems.



Illustrated below is a sectional view showing construction of "Milvaco" Thermostatic Traps. Embodying every desirable feature of successful radiator return traps and incorporating features exclusive in "Milvaco" traps, this product is a most desirable asset to a heating system. **Send for Bulletin No. 23.**

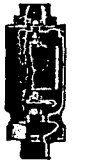
Roughing-in Dimensions and Capacities

Fig. No.	Capacity Sq. Ft. Rad.	Pipe Conn.	A Center Line Outlet to End of Spud	B Face of Outlet to Center of Spud
0	75	½"	2¼"	1⅝"
1	200	½"	3¼"	2"
2	500	¾"	3¼"	2⅜"

NOTE.—The standard roughing-in dimension, "A" for ½ in. traps as adopted by the Heating and Piping Contractors' National Association, is 3¼ in. which standard we adhere to. We can, however, upon special request, supply traps with this dimension any length from 2⅝ to 4 in.

Send for Bulletins showing complete line of specialties.

"Milvaco" Air Eliminator



A heavy substantial float vent for use on heating systems or apparatus where rapid elimination of air is necessary, and where passage of both steam and water must be prevented.

Made in ¼ to ¾ in. sizes.

Send for Bulletin No. 26

"Milvaco" Quick Vent



For use at high points on any installation where a large volume of air must be rapidly vented.

A large substantial vent for heavy duty service.

Vents completely at high or low pressures, and the check valve prevents the return of air into the system.

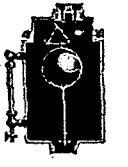
Construction the same as Air Eliminator, eliminating the float.

Made in ½ and ¾ in. sizes.

Send for Bulletin No. 26

"Milvaco" Boiler Return Trap

An ideal trap for use on vapor systems for returning water of condensation to the boiler. Positive in action; noiseless in operation; and mechanism not dependent upon action of springs.



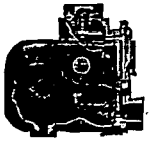
Capacity 4000 sq. ft. direct radiation.

Pipe connection 2 in.

Steam and Vent connections ½ in.

Send for Bulletin No. 25

"Milvaco" Drip and Blast Traps



"Milvaco" Drip and Blast Traps are a combination float and thermostatic trap which drip any main or riser on any heating system or apparatus where it is necessary to positively eliminate both air and water and close against steam. Not dependent upon temperature for action. Guaranteed to eliminate drip troubles.

Made in ½ to 2 in. sizes, inclusive.

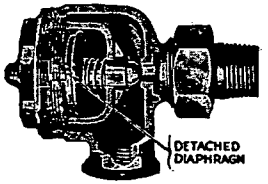
Send for Bulletin No. 27.

Monash-Younker Co., Inc.

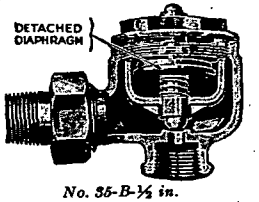
ESTABLISHED 38 YEARS

CHICAGO NEW YORK

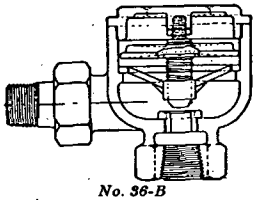
MONASH THERMOSTATIC RETURN LINE TRAPS



No. 35-A-½ in.
Made in Angle only.



No. 35-B-½ in.
Made in Angle, Right, Left and Straightway.



No. 36-B
Made in Angle only.

The working parts or "ELEMENT" of MONASH Thermostatic line of Traps are described on following page.

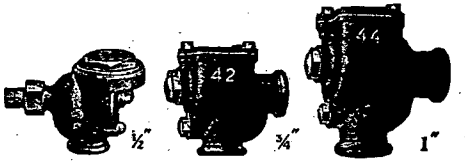
Designed to overcome the various faults of ordinary return line traps, the MONASH have proven their efficiency in rigid tests in actual operation over a period of *Thirteen Years* in many large buildings.

When MONASH Traps are specified the responsibility of the heating engineer ceases because they are *Guaranteed in Writing for Ten Years*—for pressure not to exceed Ten (10) lbs.

The No. 35 Trap can be furnished with either a vertical or horizontal seat as illustrated above.

No. 35 A	or B ½ in.	200 sq. ft. 65 lbs. water per hour
No. 36 B	¾ in.	350 sq. ft. 108 lbs. water per hour
No. 36 B	¾ in.	590 sq. ft. 160 lbs. water per hour
No. 36 BX	¾ in.	800 sq. ft. 280 lbs. water per hour

Monash Thermostatic Heavy Duty or Drip Traps for 25 lbs. Pressure



MONASH thermostatic special heavy duty or drip traps are made with **dirt-pocket, clean-out** and **by-pass.** Vertical seat and diaphragm outside the steam chamber. Especially suitable for **blast coils, dry kiln coils, main drips, dryers, laundry machinery** and all points where large quantities of condensation is to be handled.

No.		40	42	44
Size	inches	½	¾	1
Sq. Ft. of Radiation		350	1500	4000
Water per Hour	pounds	108	475	1250
Net Weight	pounds	3.25	5.00	7.50

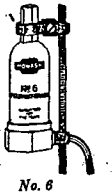
Monash Guaranteed Automatic Air Valves



No. 1

MONASH No. 1, all metal, non-adjustable automatic air valve in which the base and nipple are in one casting—no soldered or sweated joints to come apart.

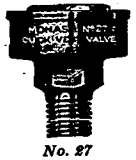
MONASH No. 6, four-way-drain, lock-shield, automatic air valve with all working parts above opening to radiator. Self-cleaning; no flooding of floors and other damage.



No. 6

Specify MONASH Valve holder with valve.

Monash Quick Venting Valves



No. 27

For mains and risers the MONASH No. 27 thermostatic quick venting valve is desirable. Has heavy brass body and cover, phosphor bronze thermostatic diaphragm.

Operates automatically at all pressures up to 10 lb.

Insures rapid steam circulation. Closes against steam, but does not close against water.

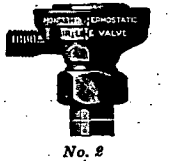
Connections are ⅜ in., 1 lb. net weight.

Monash Thermostatic Air Line Valves

for drip or air line systems; also for venting vento stacks and blast coils.

Is rapid in action and positive in results, passing all air but closing tightly against steam.

Made of brass, white plated; the No. 2 is ¼x¼ in., the No. 3 is ¼x⅜ in. 1 lb. net weight.



No. 2

A WORD TO HEATING AND VENTILATING ENGINEERS

Obsolete and defective Return Line Radiator Traps can be reconstructed and made BETTER THAN NEW by inserting the MONASH THERMOSTATIC TYPE "C" ELEMENT into the old Trap Bodies.

Have your client send us an old (half-inch) Radiator Trap complete with nut and tail piece attached and if it has a screwed-in seat, we will replace it with *our own* seat and insert our MONASH Thermostatic Type "C" Element into the Trap Body and return it to *your* client for test on consignment, postpaid.

This MONASH Element consists of a Diaphragm, which is the heart of the Trap, and the construction of same is illustrated and described herewith below.

If the Trap, sent us by your client, is one that we cannot reconstruct, then we will gladly furnish a *MONASH Ten Year Guaranteed Trap Complete* with the proper length tail piece so that it will fit into the roughing-in dimensions of the old Trap and no pipe fitting need be done. **This will give you an opportunity to learn first hand all about the virtues of the MONASH Element in the old Trap Body or the MONASH Trap complete.**

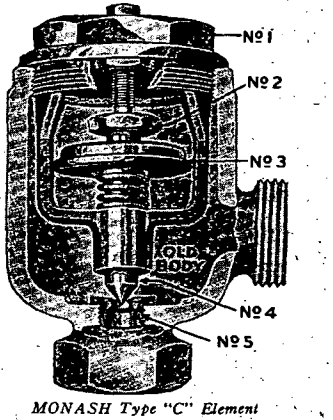
We feel confident that once you know more about the MONASH Product you may want to specify it in your work.

MONASH THERMOSTATIC DIAPHRAGM

This Diaphragm is as sensitive to the various changes of temperature as the most delicate instrument, yet, so sturdy in construction that we do not hesitate to *Guarantee it in Writing for Ten Years.*

Cover (No. 1) is cast in one piece with the guide, which permits the plunger (No. 4) to be in perfect alignment with the seat (No. 5) when closing.

Diaphragm (No. 3), the heart of the Trap, is held securely in place between the adjusting screw (No. 2) and the plunger (No. 4). It is therefore a separate and independent unit not attached to any part of the Trap Body, permitting the Diaphragm to be removed without disturbing the adjustment, as this can be done from the exterior of the Trap.



MONASH Type "C" Element

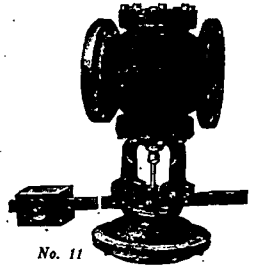
These exclusive features in the MONASH Trap are covered by United States and Foreign patents.

Mueller Steam Specialty Co., Inc.

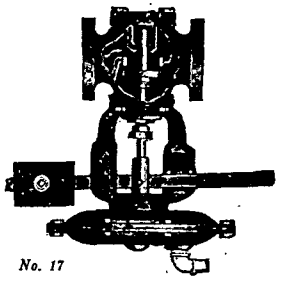
502 West 126th Street "MUESSCO" New York City

Steam, Water, Air, Oil and Gas Specialties for Heating and Power Plants

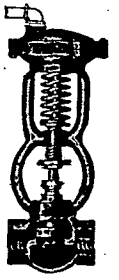
Pressure Reducing Valves—Straight Pattern and With Increased Outlet



No. 11



No. 17

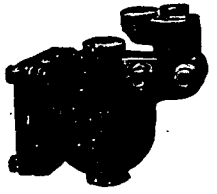


No. 21

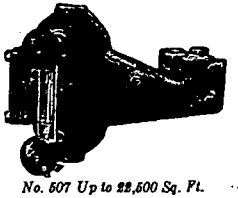
No. 11—For Vacuum, Vapor and Low Pressure Heating Systems. Initial Pressures, up to 200 lb.; Reduced Pressures, 0 to 10 lb.

No. 17 and 21—For automatic control of reduced pressures on dead-end service, requiring a tight closing valve, such as tank heaters, kitchen utensils, sterilizing apparatus, laundry equipment, kettles, cookers, driers, etc. Initial Pressures up to 200 lb. Reduced Pressures 0 to 150 lb.

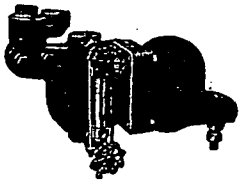
Constructed with full globe bodies. Center guide eliminates the wings on discs, and increases efficiency, assures minimum noise and prolongs the life of the seats and discs. Lever and weight operates on a steel roller bolt, assuring a most sensitive valve. Spring type furnished with special long springs for sensitive operation and wide ranges of reduced pressures.



No. 501 Junior up to 5000 Sq. Ft.

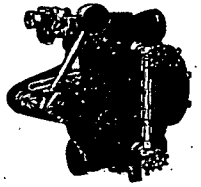


No. 507 Up to 22,500 Sq. Ft.
No. 511 for Industrial Service



No. 517 Duplex up to 22,500 Sq. Ft.

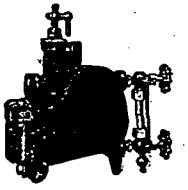
Automatic Water Feeders with a powerful leverage to control the water line in steam boilers, etc. They supply make up water to compensate for evaporation, leaks, steam utilized in process work and condensation wasted. Where condensation held up in the system eventually returns in large quantities, our Duplex type protects the boiler against flooding. All working parts of non-corrosive metal, are accessible without breaking pipe connections. Provided with an integral strainer. For steam pressures up to 100 lb., water pressures up to 120 lb.



No. 515 up to 25 lb. Pressure
No. 517 up to 150 lb. Pressure

Simple, Positive and Compact Air Eliminators and Return Steam Traps for returning the condensation from any type of low or high pressure heating system or apparatus, direct to boiler at high temperatures and discharging the air to the atmosphere.

No.	Inlet	Outlet	Steam	Vent	Sq. Ft. Rad.
1	1	1¼	¾	½	3000
2	1¼	1½	¾	½	6000
3	1½	2	1	¾	8000
4	2	2½	1¼	¾	13,000
5	2½	3	1¼	¾	25,000



No. 219 up to 30 lb. Pressure
No. 221 up to 150 lb. Pressure

Simple, Sturdy and Compact Steam Traps for draining water of condensation from steam apparatus and steam mains.

Powerful compound leverage enables them to take care of large quantities of condensation.

Equipped with strainer, water gages, air cock, blow-off and integral by-pass valve, when desired.

All working parts accessible without disturbing any pipes.

Valves sealed with several inches of water, making the escape of steam impossible.

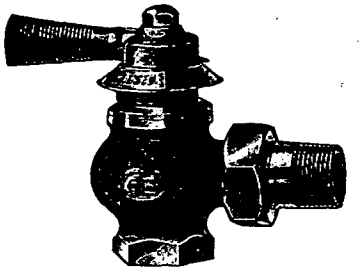
Made in sizes from ⅜ to 3 in.

CATALOGUE and BULLETINS covering our COMPLETE LINE gladly furnished on application.

O-E Specialty Mfg. Co.

Milwaukee, Wis.

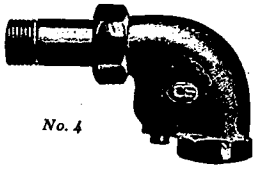
Packless Graduated Valves, Ball Check Return Elbows, Thermo-Nickel Return Traps, Air Exhausters, Vacuum Pressure Gauges, Differential Boiler Return Traps, Balanced Swing Check Valves, Venturi Hot Water Circulation Fittings and Hot Water Flow-Control Fittings.



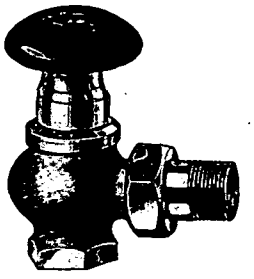
No. 2



No. 5



No. 4



No. 5

The three fittings numbered **2, 3 and 4,** are designed for the simplest and most flexible heating system ever devised. Operating on the Thermos Bottle principle, it provides VAPOR part of the time—VACUUM most of the time—PRESSURE when desired.

No. 5—O-E Mushroom Handle Packless Supply Valve.

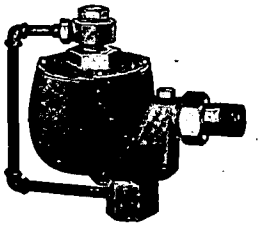
No. 6—O-E Drip and Blast Trap.

No. 7—O-E Direct Boiler Return Trap.

No. 8—O-E Thermo-Nickel Trap.

No. 9—O-E Vacu-Float Vent Valve.

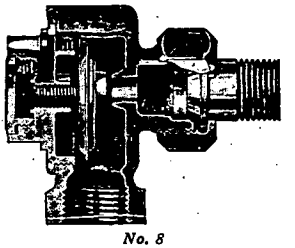
In addition to above, we manufacture a full line of Heating Specialties



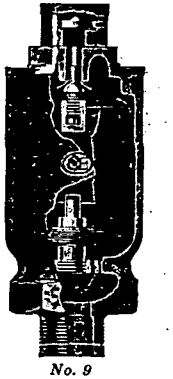
No. 6



No. 7



No. 8

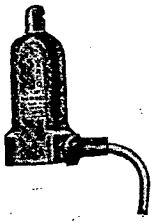


No. 9

W. A. Russell & Company

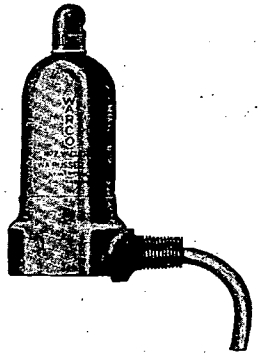
Grand Central Terminal — New York

"Warco" *Automatic Air & Vacuum* Valves



ABOVE
"Warco" No. 1
⅛ in. Side-Outlet Air Valve for Radiators

BELOW
"Warco" No. 2—Vacuum
⅛ in. Side-Outlet Vacuum Air Valve for Radiators





ABOVE
"Warco" No. 4
¼ in. Bottom-Outlet Quick Vent Air Valve for Mains and HV Stacks



LEFT
"Warco" No. 3
¼ in. Bottom-Outlet Air Valve for Mains, Coils and Risers

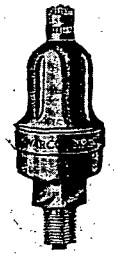
RIGHT
"Warco" No. 3-V—Vacuum
¼ in. Bottom-Outlet Air and Vacuum Valve for Mains, Coils and Risers



RIGHT
"Warco" No. 5
¾ in. Bottom Outlet, Quick Vent Air Valve, for Mains and HV Stacks

An extremely fast venting valve, with the precision of operation characteristic of the "Warco" Line. It has an exclusive adjustable air port cap that enables the Heating Contractor to balance Steam Lines when they are unequal. By adjusting the venting ports, steam will flow along the mains at approximately the same speed, getting heat to the end of all mains simultaneously.





LEFT
"Warco" No. 6—Vacuum
⅜ in. Bottom Outlet, Quick Vent Air and Vacuum Valve, for Mains and HV Stacks

This valve has the same features as the "Warco" No. 5, plus the "Warco" Vacuum principle. Many splendid testimonials to the efficiency of this vacuum principle—reports of fuel saving, more satisfactory and more constant heating assure us that the valves have no superior, regardless of price.

The complete line of seven "Warco" Automatic Air and Vacuum Valves was designed, and is produced under the personal supervision of Mr. W. A. Russell, a pioneer in the Air Valve industry, who has been designing and making volatile liquid air valves for 38 years.

Careful selection of materials, an actual test under steam conditions for the functions necessary—air, steam and water—assure perfect operation on the job. "Warco" Valves are guaranteed to give satisfaction for five years when installed under proper conditions.

Stickle Steam Specialties Co.

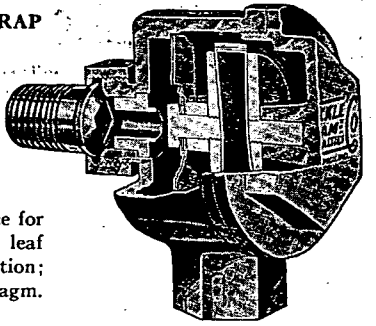
Main Office and Works, INDIANAPOLIS, IND.

NEW YORK OFFICE
280 Madison Ave., Room No. 910

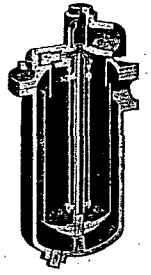
BOSTON OFFICE
52 Sudbury St.

Manufacturer of the STICKLE Open Coil Feed Water Heaters and Purifiers, STICKLE Steam Traps high and low pressure and vacuum, Pressure Regulators, Damper Controls, Back Pressure Valves, Standard Balance Valves, Vacuum Heating Specialties, Blast Coil Heaters, Heating and Ventilating Equipment, Triplex Oil and Steam Separators.

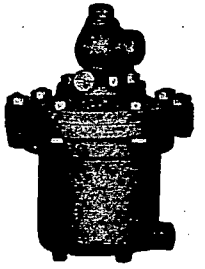
STICKLE THERMOSTATIC RADIATOR TRAP



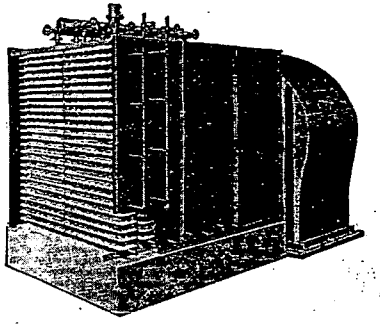
The special feature of the STICKLE Thermostatic Radiator Trap is the diaphragm; with box shape inverted heads, side walls reinforced with seamless drawn brass tubing, a solid disc protecting each head and so constructed that the diaphragm cannot get out of place. The diaphragm is so reinforced that there is no possible chance for it to become distorted or ruptured. The flat leaf bronze spring makes a positive opening action; supplementing the spring action of the diaphragm.



STICKLE THERMIC VACUUM TRAPS



Designed for draining steam headers and risers on low pressure heating systems. A Thermostatic trap will close on hot water and for this reason they will not drain a steam header. This trap is mechanically operated with positive air release. No matter what the temperature of the water this trap will handle it. This is the ideal trap for Blast Coil Service, made in sizes up to 2 inch. Send for the descriptive matter.



STICKLE VAPOR VACUUM HOT BLAST HEATER

Primarily designed to operate with the condensation from the dryers of a paper machine, for heating air to ventilate the machine room. When connected to the return line of a vacuum heating system it will maintain from 10 to 15″ of vacuum on the pump without the use of cooling water.

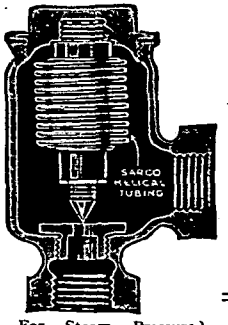
Write us regarding this heater. It has no equal. Cold air is heated and used, instead of using cooling water which goes to the sewer, the heat being lost.

Sarco Co., Inc.

183 Madison Ave., New York

BALTIMORE BOSTON BUFFALO CHICAGO CLEVELAND DETROIT PHILADELPHIA
PITTSBURGH ST. LOUIS

RADIATOR, BLAST AND STEAM TRAPS,
PACKLESS INLET VALVES, TEMPERATURE REGULATORS AND STRAINERS



For Steam Pressure from 0 to 30 lb. Fig. 9–1 can be used. It has the same capacities as Fig. 9–2 but is furnished with brass composition valve heads and seats.

SARCO STEAM TRAP No. 9

For pressures 0 to 100 lb.

For industrial purposes, hospitals, laundry and kitchen equipment. Sarco Steam Trap No. 9 consists of a heavy bronze body with a powerful motor element of helical seamless bronze tubing containing an expansion fluid.

Is of the balanced pressure type, suitable for any steam pressure from 0 to 100 lb. *without readjustment.*

Has unusually great capacity, large valve area and quick, high lift when discharging. Cannot air bind.

Write for Booklet No. HV-261.

Size In.	Price, Each Type No. 9–2	Price, Each Type No. 9–1	Dimensions Inlet to Outlet	Capacity Lb. per Hour
½	$*8.50	$ 7.50	1¾″	500
¾	11.50	10.50	1¾″	600
1	14.50	13.50	2″	800

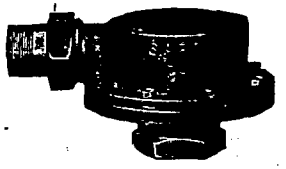
SARCO HIGH AND LOW PRESSURE BLAST TRAPS

No. 9-3 and 9-4 (entirely Thermostatic)

This Heavy-Surface or Blast Trap is for draining steam coils of hot-water tanks, vento stacks and main drip lines; also where a large capacity trap is required such as for draining coils in dryers, vacuum pans, heating coils, cooking vessels, etc.

Will handle great flows of condensation without loss of steam. Is entirely thermostatic, so removes the air as well as water.

Operates on the same principle as the Sarco Steam Trap No. 9-2.



No. 9–3, PRESSURES 0–30 LB.
Brass Composition Valve Head and Seat

List Prices F. O. B. Bethlehem, Pa.	Capacities Lb. per Hour
1″ $25.00	1,000
1½″ 27.50	1,000
1½″ 30.00	1,500
2″ 37.50	2,000

Can be furnished in offset patterns at same prices.

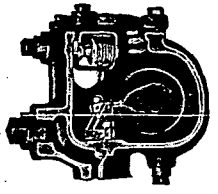
No. 9–4, PRESSURES 0–100 LB.
Monel Valve Head and Seat

List Prices F. O. B. Bethlehem, Pa.	Capacities Lb. per Hour
1″ $30.00	1,250
1¼″ 32.50	1,250
1½″ 35.00	3,250

Write for Blast Trap and Heavy Service Booklet.

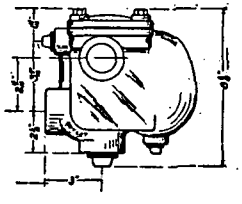
F.T. 1 (Float and Thermostatic)

Recommended for live drips, large heating units, vento stacks, hot water tanks, etc. Two inlet and two discharge connections tapped 1¼ in. are provided and can be adjusted to the size specified. The thermostatic by-pass releases air. The under-slung valve head insures large capacity and reduces wear.



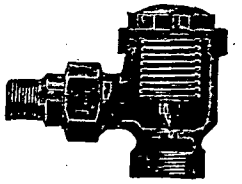
Capacity in pounds of water per hour at pressure differential per square inch.

½ lb.	550	5 lb.	1600
1 lb.	725	7½ lb.	1800
2 lb.	1000	10 lb.	2000



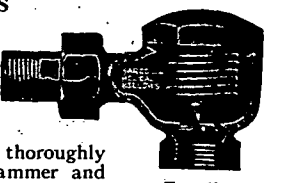
List Price: ¾ in. 1 in., 1¼ in., $25.00
F. O. B. Bethlehem, Pa. Weight: 15 lb.

SARCO RADIATOR TRAPS



Type E

For vacuum, vapor and low-pressure heating systems. The Sarco is of the thermostatic type, using Seamless Helical Bellows and a volatile liquid filling. Its positive action keeps radiators thoroughly drained, preventing water hammer and air binding.



Type H

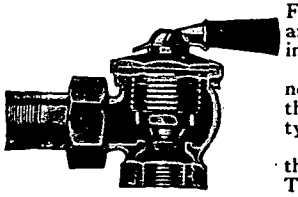
Helical Bellows is phosphor bronze. It has a high lift, insuring free discharge, a maximum closing pressure and an unusually long life. Body is heavy brass, nickel plated. Can be used on all pressures up to 25 lb. without adjusting.

Write for Booklet HV-125.

List Prices F.O.B. Bethlehem, Pa.			Dimensions Center Inlet to Outlet	Dimensions Center Outlet to Face of Outlet	Capacity—Direct Radiation Vapor System Sq. Ft.	Capacity—Direct Radiation Vacuum System Sq. Ft.
Type E	½″	$ 6.00	3½″	1½″	200	250
Type E	¾″	8.00	3½″	1½″	600	800
Type E	1″	15.00	3⅝″	2″	1500	1800
Type H	½″	5.00	3¼″	1½″	125	150

Angle, straightway and offset types are furnished at same prices.

SARCO PACKLESS INLET VALVE



For use on vapor and vacuum heating systems.

This valve cannot leak as it is of the true Packless type.

By the use of the Sarco Helical Tubing it eliminates the necessity for packing of any kind.

Valve opens or closes with a three-quarter turn and the pressure is always even, smooth and regular. Easy to turn. Dial is distinctly marked.

Has heavy brass, well-nickeled body. Furnished with lever or round moulded handles.

Write for Booklet HV-151.

List Prices F. O. B. Bethlehem, Pa.		Center Inlet to Outlet	CAPACITIES Feet Direct Radiation
½″	$5.50	3″	up to 40 sq. ft.
¾″	6.00	3″	41 to 75 sq. ft.
1″	7.50	3½″	76 to 125 sq. ft.
1¼″	9.50	3½″	126 to 200 sq. ft.

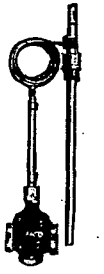
SARCO TEMPERATURE REGULATORS

Sarco Temperature Regulators are self-contained and self-operating. No auxiliaries such as air, water or electricity are required. They operate thermostatically by the expansion of a heavy hydro-carbon oil and are positive in action. Will operate steam, gas or water valves and can also be supplied to open with rise in temperature.

They can be used for hot water tanks, cold storage plants, dry room or kiln control and for any specified temperature from 30 to 300 deg. fahr.

Sarco Regulators can also be furnished to meet special conditions. Inquiries are invited.

Write for Booklet HV-55.



Type TR-21

SARCO SELF-CLEANING STRAINER

For Steam, Water and Oil Lines. Write for Booklet HV-225.

SARCO AIR ELIMINATOR

Has a capacity of 15,000 sq. ft. of Direct Radiation based on one ounce pressure. Has ¾ in. port area and is fitted with union connection.

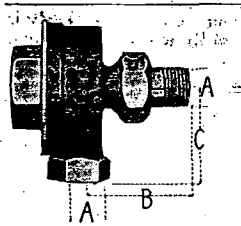
Sterling Engineering Co.

1626-44 Holton Street — **Milwaukee, Wis.**

SALES OFFICES

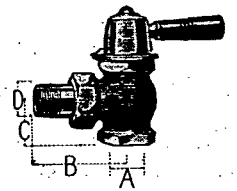
Atlanta, Ga.	Detroit, Mich.	Louisville, Ky.	Pittsburgh, Pa.
Birmingham, Ala.	Erie, Pa.	Minneapolis, Minn.	Portland, Ore.
Boston, Mass.	Fort Wayne, Ind.	New Orleans, La.	Salt Lake City, Utah
Buffalo, N. Y.	Grand Rapids, Mich.	New York, N. Y.	Savannah, Ga.
Chicago, Ill.	Hartford, Conn.	Oklahoma City, Okla.	St. Louis, Mo.
Cleveland, Ohio	Indianapolis, Ind.	Peabody, Kan.	Toledo, Ohio
Dallas, Texas	Kansas City, Mo.	Philadelphia, Pa.	Toronto, Can.
Denver, Colo.	Los Angeles, Calif.	Pine Bluff, Ark.	Washington, D. C.

Send for Bulletins describing complete line



Sterlco Thermostatic Trap

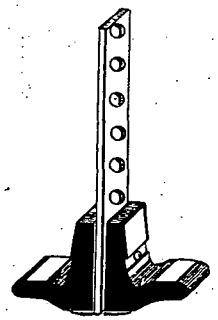
A	B	C	Capacity
½"	2⅝"	2⅛"	200 sq. ft.
¾"	2¾"	2½"	500 sq. ft.
1"	3½"	3"	1000 sq. ft.



Sterlco Packless Valve

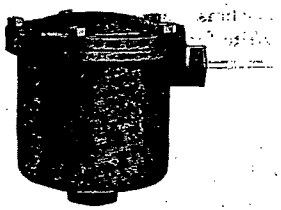
A	B	C	D	Capacity
½"	2⅝"	1¼"	½"	24 sq. ft.
¾"	2¾"	1⅜"	¾"	70 sq. ft.
1"	3¼"	1½"	1"	150 sq. ft.
1¼"	3½"	1¾"	1¼"	200 sq. ft.
1½"	4¼"	1¾"	1½"	300 sq. ft.

Can be furnished with Mushroom handle or with loose key.



Ketchum Sterlco Kwic-Lift Hanger

For supporting ceiling radiators.



No. 73 Sterlco Unit Heater Trap

¾ in. pipe connections. Weight 10½ lb.

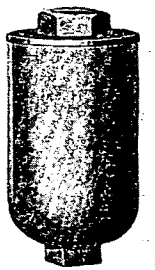
Capacity 400 lb. per hour at 1 lb. pressure or 1700 lb. per hour at 15 lb. pressure.

Maximum Steam pressure 15 lb.

No cooling leg required.

Drains completely when cold.

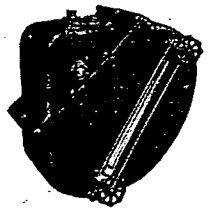
Also used as a Drip Trap



Sterlco Vacu Float Vent

For use on heating systems where rapid elimination of air is necessary and where passage of water must be prevented. ½ in. pipe connection.

Capacity 3000 sq. ft.



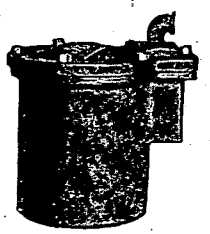
Sterlco Return Trap

For use on vapor systems for returning condensation to boiler. Capacity 3000 sq. ft. Direct Radiation.

Pipe connections 1½ in.

Steam inlet connection ¾ in.

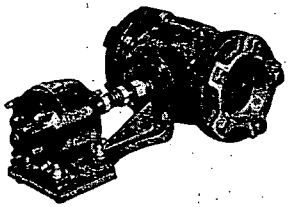
Vent connection ½ in.



Sterlco Air Eliminator

For use on vapor systems of 1000 sq. ft. of direct radiation or less where return line can be located at least 27 in. above water line in boiler. Inlet connection 1 in.

Outlet connection ¾ in.



Ketchum Sterlco Compeller

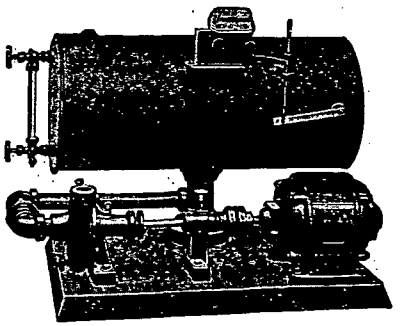
For stimulating the circulation of water in hot water heating systems or on domestic hot water or ice water circulating systems.

Size of valve body 4 or 6 in.

4 in. Size furnished with companion flanges tapped 1½, 2, 2½, 3, 3½ or 4 in. as required. Size of motor 1/10 hp. Weight 80 lb.

6 in. Size furnished with companion flanges tapped 4½, 5 or 6 in. as required.

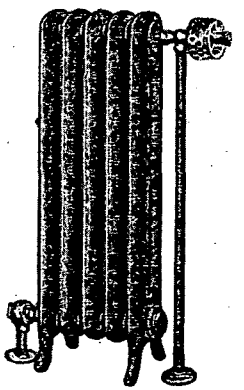
Size of motor ⅙ hp. Weight 200 lb.



Sterlco Condensation Pump

No.	Sq. Ft. Radiation	H. P.	Pressure Lb.
28	2000	¼	15
38	4000	¼	15
48	8000	½	15
58	16000	½	15
68	32000	1	15
78	48000	1½	15
88	64000	2	15
168	32000	1½	25
178	48000	2	25
268	32000	2	35
278	48000	3	35
288	64000	3	35

These pumps are also built for 50 and 100 lb. pressure.



Sterlco Roys Thermotrol

A self-contained, automatic temperature control valve not requiring air piping, mechanically driven air compressor or electrical connections to operate it.

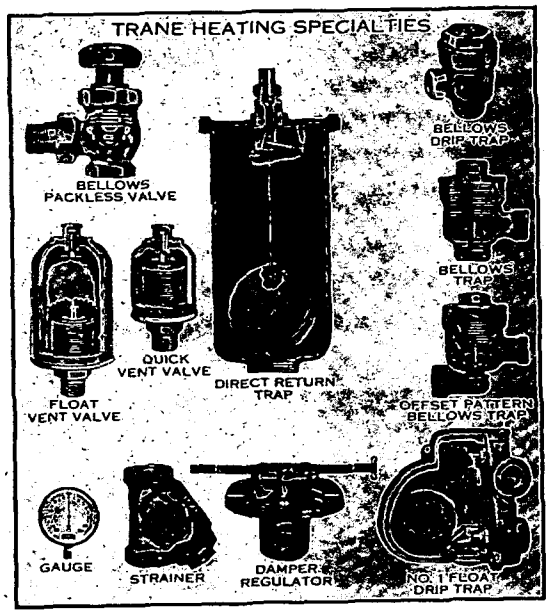
¾ in. Capacity 70 sq. ft. of Direct Radiation
1 in. Capacity 150 sq. ft. of Direct Radiation
1¼ in. Capacity 250 sq. ft. of Direct Radiation
1½ in. Capacity 300 sq. ft. of Direct Radiation

The Trane Company

La Crosse, Wis.

See Pumps, page 727; Unit Heaters, page 638; Heat Cabinets, page 622, 623
Heating Specialties, page 786, 787

BRANCHES IN PRINCIPAL CITIES



TRANE HEATING SPECIALTIES

Bellows-Packless Valves are made in standard sizes from ½ to 2 in. They are strictly packless. A Trane 10-corrugation bellows makes this feature possible. Valves are especially constructed to fill the requirements for a valve that can be used on an industrial installation where vibration is prevalent as well as on residence jobs. Body is brass. Nickeled, highly polished trimmings. In addition to the standard valve illustrated special right or left hand corner-pattern valves with these general features are also available in the ¾ in. size. These are especially suitable for Concealed Heater installations.

Trane Float Vents are designed to close against steam, water, and vacuum. Full quarter-inch venting ports insure unlimited capacities. These vents are furnished with a standard Trane 14-corrugation bellows. ¾ in. pipe connection only. In addition to regular venting work on heating systems, Trane Vents are frequently used for special requirements such as on blast heaters, dryers, and other commercial equipment.

Trane Quick Vents do the same work as Float Vent Valves except that they close against steam and vacuum only. ¾ in. pipe connection. Contain standard 14-corrugation Trane Bellows.

Trane Gauges are of the spring Bourdon type. Small gauges (4½ in. in diameter) are calibrated from 18 in. vacuum to 30 lb. pressure. Large gauges (8½ in. in diameter) for high boilers and dark boiler rooms are calibrated from 30 in. vacuum to 30 lb. pressure.

Trane Strainers are furnished in four sizes, ½, ¾, 1, 1¼ in. They are equipped with a removable strainer screen for easy cleaning.

Trane Direct Return Trap is essentially a safety device. No matter how carelessly the system is fired this Direct Return Trap returns the water to the boiler regardless of pressure.

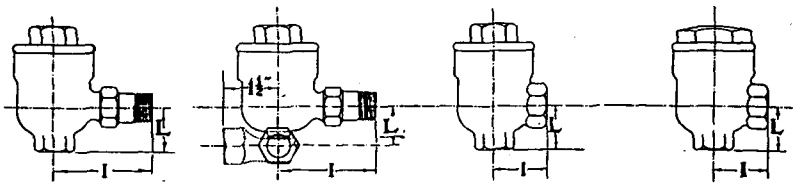
Trane Damper Regulators are sensitive to the slightest change in boiler pressures. An ounce of pressure is sufficient to operate this regulator which results in even temperatures at all times.

Trane Bellows Radiator Traps are equipped with the standard Trane 14-corrugation bellows. These bellows are made without seams or joints of any kind. Trap bodies are made of steam brass. Guaranteed operating range from any vacuum to 25 lb. pressure for low pressure traps and from 26 lb. to 125 lb. for high pressure traps. All traps are factory adjusted and carefully tested so that operation of each and every trap is absolutely uniform.

Trane Bellows Drip Traps are available in both high and low pressure styles, i.e., with pressure ranges from any vacuum to 25 lb. and from 26 lb. to 125 lb. These traps are fitted with 14-corrugation bellows members and are desirable for use on systems where a high vacuum is carried on the return and it is necessary to drop the temperature of the condensate.

Trane Offset Pattern Trap is exactly the same in construction as the bellows radiator trap except that it is fitted with an adjustable outlet connection that can be swung to any position desired, eliminating the necessity of using right, left and straightway pattern traps.

Trane Float Drip Trap. This trap is especially designed for unit and blast heater installations where rapid draining increases the capacity of the unit. Thermostatic air by-pass eliminates all possibility of air binding. Water discharge is entirely regulated by float control. High temperatures have no effect upon the operation of this trap.



Angle *Offset* *High Pressure* *Drip*

SIZES, CAPACITIES, ETC., OF TRANE RADIATOR TRAPS

Size	Capacity in Sq. Ft. at Various Pressure Differences							DIMENSIONS, INCHES		
	4 oz.	8 oz.	1 lb.	2 lb.	5 lb.	25 lb.		Size	L	1
½"	200	375	395	560	880	1960	Angle	½ and ¾	1 13/16	3¼
							Angle	1	1¾	3 3/8
							Offset	½ and ¾	1 13/16	3¼
¾"	400	585	770	1080	1720	3850	High Pressure and Drip	½ and ¾	1 13/16	1 11/16
1"	800	1125	1600	2250	3560	7950	High Pressure and Drip	1	1¾	2

Sizes conform to recommendations of *Heating and Piping Contractors' National Association.*

Vapor Engineering Company

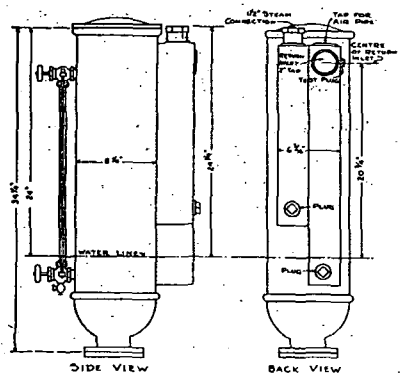
489 Fifth Avenue
New York City
Chas. E. Scott—R. C. Willis

10 South 18th Street
Philadelphia, Pa.
J. W. Glassey—M. S. Buck

VECO VAPOR SPECIALTIES

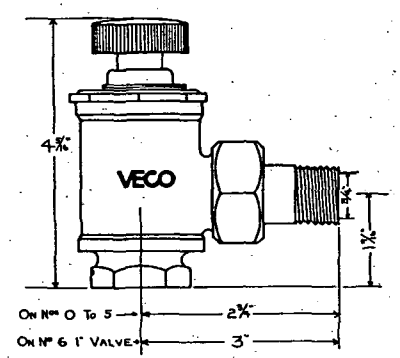
Non Mechanical and Positive in Operation

Engineers for the design of "open-to-atmosphere" vapor heating systems for factory, public and residential buildings, regardless of size, construction or location. Veco Vapor specialties are the result of 21 years of specialization in vapor heating work



VECO GOVERNOR

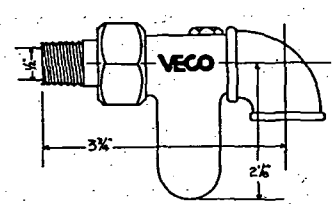
Combining, Safety Valve, Air Eliminator and positive control of Boiler draft, Gas supply valve, or Oil Burner



VECO SUPPLY VALVE

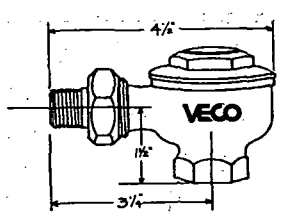
Packless, Leakless, Graduated.

¾ in. Nos. 0 to 5 up to 133 sq. ft. inclusive.
1 in. No. 6 up to 140 to 160 sq. ft. inclusive.



VECO RETURN SEAL

No moving parts. For all standard vapor work



VECO THERMOSTATIC TRAP

For Central Plant work, Ventilating Units, etc.

Full cooperation is offered to Architects, Engineers and Contractors in the planning of Veco Systems which are fully Guaranteed as to material—and satisfactory operation.

ESTABLISHED 1888

WARREN WEBSTER & COMPANY

Pioneers of the Vacuum System of Steam Heating

Camden, N. J. **Branches in over 50 Cities**

Manufacturers of Webster Systems of Steam Heating and Webster System Equipment—More Than 46,000 Installations—Webster Series '78' Traps for "Process" Steam Pressures—Steam and Oil Separators and Expansion Joints

Webster Products

Webster Vacuum and Type "R" Systems of Steam Heating.

Webster System Apparatus: Including Sylphon Traps; Diaphragm (No. 7) Traps; Modulation Supply Valves; Sylphon Quick-Opening Packless Valves; Dirt Strainers; Dirt Pockets; Drip Traps; Heavy-Duty Traps; Double Service Valves; Water Accumulators; Expansion Joints; Lift Fittings; Suction Strainers; Vacuum Governors; Hy-lo Traps and Controllers; Damper Regulators; Vent Traps and Vent Valves; Boiler Return Traps; Air Separating Tanks.

Steam and Oil Separators.

Webster Series '78' Traps for "Process" steam pressures (10 to 100 lb. per sq. in.).

Webster Service

—delivered through more than 50 Branch Offices, places at the disposal of engineers, architects, and heating contractors accurate, comprehensive information resulting from the extensive experience of this organization.

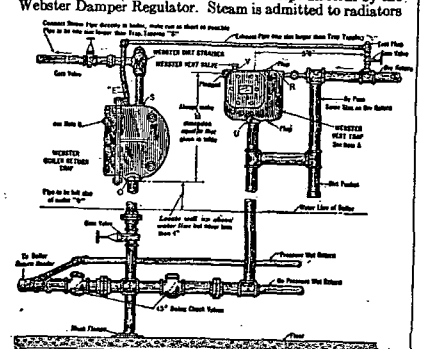
Webster Vacuum Systems

—are particularly suited to large buildings, or where "process" steam is used and the exhaust utilized for either direct radiation, or in combination with blast coils or unit heaters . . . operating on either low-pressure live steam or exhaust steam, or a combination of both.

Webster Type "R" System

A two-pipe, open return line, low pressure steam heating system adaptable to almost every type of building, except the very largest, where Webster Vacuum Systems are used. For installations from 500 to 32,000 sq. ft. of direct radiation. The only limitation is the necessity for a basement or other depression so that the boiler may be placed with its water line below the level of water of condensation flowing back to it. The combination of the Webster Boiler Return Trap and Webster Vent Trap incorporated in this system provides maximum safety with open return line simplicity.

Operation: Pressure at the boiler is kept uniform by the Webster Damper Regulator. Steam is admitted to radiators by Webster Modulation Valves or Webster Sylphon Valves. Condensation and air are completely discharged through Webster Return Traps which insure absolute silence and prevent waste. Air and condensation are carried to Webster Basement Equipment consisting of the Webster Boiler Return Trap and Vent Trap in combination. Air escapes through the Webster Vent Valve. The Webster Boiler Return Trap returns water to boiler whenever pressure exceeds a few ounces.

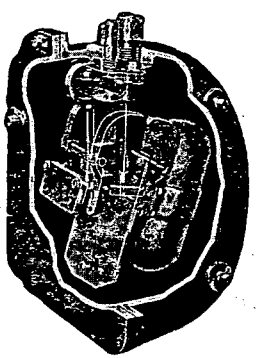


Conventional Arrangement of Piping Around Webster Boiler Return Trap, Sizes 023 to 323, in the Webster Type "R" System of Steam Heating

TABLE I. Webster Type "R" System Basement Equipment

Size of Boiler Return Trap	Rating, Sq. Ft. Direct Radiation	Number of ½-in. Vent Valves	Size of Vent Trap
0023	1500	1	0023
023	2500	1	023
123	4000	1	123
223	8000	2	223
323	16,000	3	323

For installations over 16,000 sq. ft., two Boiler Return Traps and a Duplex Vent Trap are used. See Webster Service Details.



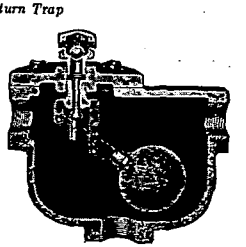
Webster Boiler Return Trap

Webster Boiler Return Traps

A positive trap which insures return of water to the boiler. A float-controlled valve admits steam from boiler to equalize pressures in trap and boiler. As waterline of trap is above that of boiler, water flows by gravity to boiler. Float closes valve when trap empties.

Webster Vent Traps

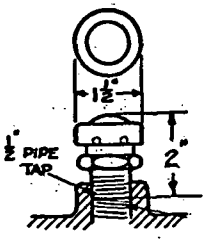
Contains a ball vent valve which permits escape of air but prevents its return. Makes possible operation for hours at a time at less than atmospheric pressure.



Webster Vent Trap

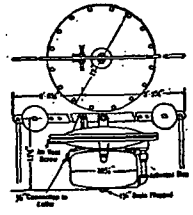
In the following columns are listed Webster Systems Equipment. Roughing-in dimensions are given in inches. Consult Webster Service Details for complete installation instructions.

Webster Vent Valves



Refer to Table I for number to use in connection with sizes of Vent Traps.

Webster Damper Regulator



Dimensions are given on illustration

Webster Sylphon Packless Q.O. Valves

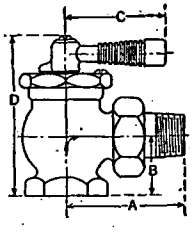


TABLE II
Dimensions

Size	A	B	D
½	2⅝	1¼	3⅜
¾	2¾	1⅜	3⅞
1	3⅛	1¾	4¾
1¼	3⅝	1⅞	4⅞
1½	3⅞	2⅛	5⅜
2	4⅜	2⅛	5⅞

Webster Type "W" Modulation Valves

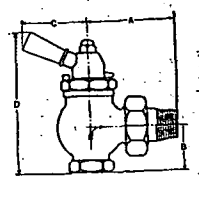
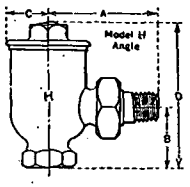


TABLE III
Dimensions

Size	A	B	D
½	2¾	1¼	4⅛
¾	2¾	1½	4⅝
1	3⅛	1¾	5½
1¼	3½	2	6

Webster Return Traps



*Sizes 513 and 523 can be supplied with ⅓-in. inlet nipples.

TABLE IV
Dimensions

Size	A	B
½–512	3⅛	1⅝
¾–513*	3⅛	1¾
½–522	3¼	1⅞
¾–523*	3¼	2
¾–533	4	2⅛
1–534	4	2⅛
1–544	4¼	2⅛
1½–545	4½	2⅛

Webster Double Service Valves

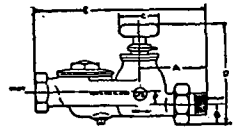


TABLE V
Dimensions

Size	E	B
¾	9⅛	1
1	9½	1¼
1¼	10½	1⅜
1½	10⅝	1⅝

Webster Dirt Pocket—Series 26

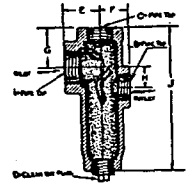


TABLE VI
Dimensions

Size	A	B	C	E	F	G
526	1¼	1	1	1¾	1⅜	1⅞
826	2	1¼	1¼	2⅛	1⅜	2⅛
1026	2½	1¼	1½	2⅝	1¾	2¾
1226	3	1¼	1½	2¾	1¾	3⅛

Webster Dirt Strainers—Series 18

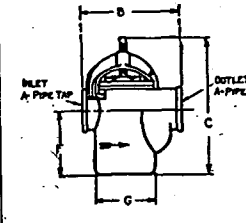


TABLE VII
Dimensions

Size	B	C	F
½ or ¾	4¼	6	2¾
1 or 1¼	5½	7⅜	3½
1½ or 2	7¼	9¼	4¾

Webster Heavy Duty Trap—Series 19T

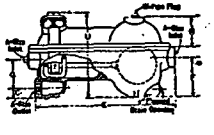
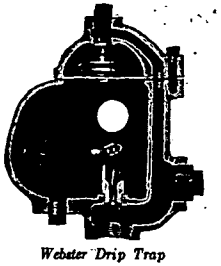


TABLE VIII
Dimensions

Size	A	C	E
0019T	¾	1	12⅞
019T	1	1	15
119T	1¼	1⅜	18⅜
219T	2	1⅜	19⅞

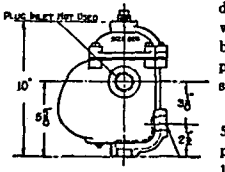
Webster Drip Trap—Series 026

A heavy duty trap, handling large volumes of condensation and air. Compact and light in weight. Suited for drips of mains, unit heaters and similar applications. Specifications calling for a heavy-duty float-type trap is fully met, while the advantages of the thermostatic element and ease of installation are both retained.



Webster Drip Trap

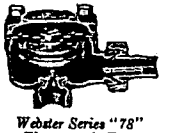
Outlet openings on both end and the bottom permit discharge of water, or water and air, either vertically or horisontally. An opening in the cover of the trap is provided so that air may be discharged separately when desired. In the bottom of the trap is a plugged opening which serves as a cleanout.



Dimensions

Ratings range from 500 lb. per hour at ¼ lb. pressure difference to 1800 lb. at 10 lb. pressure difference.

Webster Series "78" Thermostatic Traps



Webster Series "78" Thermostatic Trap

Webster Series "78" Thermostatic Traps have been developed to meet the needs of users of "process" steam at 10 to 100 lb. per square inch. When installed in accordance with the recommendations of Webster Service, they provide the answer to a multitude of problems of efficient discharge of air and water of condensation from process-steam using equipment. Increased production through quicker heating-up and higher maintained temperature of heating surfaces result.

DESIGN AND CONSTRUCTION: Unusual construction features include automobile-type copper-asbestos gasket, heavy-gauge Monel metal diaphragm, renewable stainless steel valve piece and seat, expanded opening for quiet operation, cast steam brass body, and hot forged brass cap bolted on with Monel metal tap bolts.

SIZES AND TYPES: Webster Series "78" Thermostatic Traps are made in ⅜, ½, ¾, and 1 in. sizes and in two pressure classes. Class 2 Traps are designed for pressures from 10 to 50 lb.; Class 3 Traps for 50 to 100 lb. pressures

RATINGS: The range of application of Webster Series "78" Traps is limited only by the following three factors: (1) Pressure of 10 lb. (or less) to 100 lb. per sq. in. (2) Volume of condensation ranging from 60 to 1210 lb. of water. (3) Not to be used with superheated temperature.

TABLE IX
Ratings of Webster "78" Thermostatic Traps

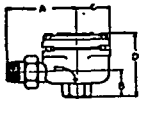
Size of Trap	Size of Tappings		Class 2 Working Pressures up to 50 lb. per sq. in.				Class 3 Working Pressures, 50 to 100 lb.					
	Inlet	Outlet	Pressure Differential, Pounds per Square Inch				Pressure Differential Pounds per Square Inch					
			10	20	35	50	20	35	50	65	80	100
			Pounds of Water per Hr.				Pounds of Water per Hour					
780	⅜"	⅜"	20	40	80	120	30	50	68	85	100	115
782	½"	½"	60	95	140	185	75	110	145	180	210	245
783	¾"	¾"	130	225	330	435	165	245	325	405	470	545
784	1"	1"	300	465	685	900	375	550	725	900	1040	1210

NOTE.—The pressure differentials given in this table refer to pressures existing at the inlet of the trap and in the return line.

APPLICATION: Webster Series "78" Thermostatic Traps may be used to advantage in hundreds of different applications. Most of these fall into three groups.

1. To discharge both air and water of condensation from single pieces of apparatus within its capacity.
2. For installation on each unit of a battery—as for example a battery of kettles instead of the old fashioned method of trying to handle the entire battery through one "master" trap.
3. For venting air *only* from apparatus formerly provided with handcock or other similar inadequate means, and where volume of condensation is handled by a "bucket type" trap.

TABLE X
Dimensions



No. of Trap	A	B
780	2⅜	1¾
782*	3⅛	1⅞
783	3¾	1⅞
784	4⅝	2

Class 2 Trap—10 to 50 lb. pressure.
Class 3 Trap—50 to 100 lb. pressure.
*782 Trap furnished on special order with ⅜-in. nipple to fit the standard ½-in. union nut. Other dimensions unchanged.

WHERE USED: Webster Series "78" Thermostatic Traps are used in heating systems; Sterilisers; Cooking and Laundry Apparatus; Textile Apparatus; and in Woodworking and Process industries. Ask for 4-page data form to use in analysing your "process" steam problem.

Webster Series "78" Dirt Strainer

The Webster Series "78" Dirt Strainer has been provided to be placed ahead of every Webster Series "78" Thermostatic Trap located at a drip point in the supply piping or attached to apparatus which is likely to contain core, sand, pipe scale or sediment.

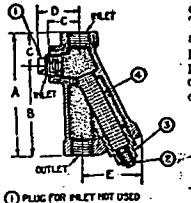


TABLE XI
Dimensions

Size, In.	A	B
782–½	4½	3⅜
783–¾	4¹³⁄₁₆	3½
784–1	5⅝	4⅛

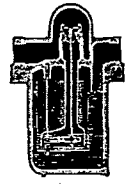
Wright-Austin Co.

Exhaust Heads
Water Columns
Pump Governors

315 W. Woodbridge Street
Detroit, Mich.
Representatives in Principal Centers

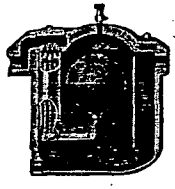
Made to order
Separators
Air Traps

"Airxpel" Bucket Type Steam Trap
0 to 300 lb.



Expels entrained air automatically. Unusually large capacity. Has exceptionally long life without repairs, because of simple, one lever construction. All parts are accessible at all times. Straight line horizontal pipe connection, making it easy to install; low weight, hangs on the pipe line. Monel metal valves and seats in a valve holder which regrinds the valve as the Trap operates, keeping it steam tight.

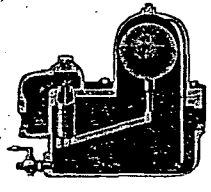
"Emergency" High Pressure Steam Trap
0 to 250 lb.



Three valve Trap with exceptionally large capacity, at high loads and no wire drawing at low loads. No change of valves or adjustment of any kind from 0 to 200 lb. Capacity increases with pressure. All internal mechanism attached to and removable with the cover. Straight line horizontal connections. Strong nickel float. An exceptionally reliable Trap for shipment to foreign lands or out of the way places.

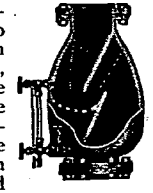
"Victor" Low Pressure Steam Trap
0 to 20 lb.

Especially designed for low pressure. The valve opens outward with the flow of condensate, giving enormous capacity. Will discharge without pressure, which is valuable in starting up a cold system. An excellent oil and grease Trap. Very simple in construction, having only three moving parts. Used extensively on central station heating systems, on vento coils and on vacuum returns, in which case, the Trap is provided with a thermostatic air valve.



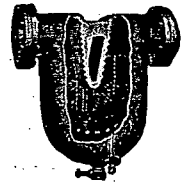
The three Separators illustrated here are part of one of the most complete lines of types and sizes in the world. These include cast semi-steel Separators, cast steel, riveted steel and welded steel Separators made in all sizes for all classes of service.

Type "A" Vertical Steam Separator
0 to 250 lb.



For average service. Will eliminate dirt and moisture from steam down to ½ of 1 per cent; cast in one piece and self cleaning, requiring no maintenance after installation. The Type "A" has been standard for 32 years and there are many thousands in successful use. Installed just ahead of the throttle of an engine; it improves efficiency, checks vibration and prevents accidents.

Type "B" Horizontal Steam Separator
0 to 250 lb.



Can be placed close to walls or ceiling, because body of Separator hangs below pipe line. Self-cleaning, cast in one piece, no maintenance required. Will remove moisture down to ½ of 1 per cent.

Type "S" Horizontal Oil Separator
0 to 50 lb.

Cast in one piece, self-cleaning, requires no maintenance. Will eliminate oil from exhaust steam or gas down to 0.3 grain per gallon, which is a mere laboratory trace. Exceptionally large baffles and steam area, which increase efficiency. Thousands in use all over the world.



Webster Tallmadge & Co., Inc.

50 Church Street
New York, N. Y.

HIGH EFFICIENCY HEATING SYSTEMS

Tallmadge Methods insure better economy, comfort, health and proficiency from correct heating of buildings, and in process work in industrial plants.

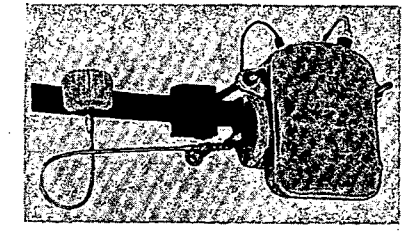
The first cost of Tallmadge Heating Systems is lower and the complete story is told in the Bulletin "Correct Heating," which also covers Electrical Control of Zoned Orifice Distribution.

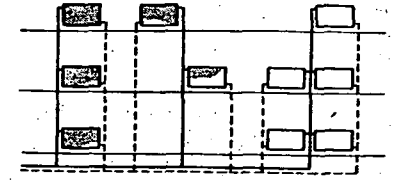
Some of the outstanding advantages of the orifice type of steam distribution are:

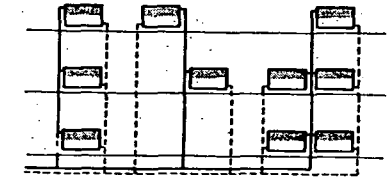
1. Low steam consumption of radiators, in mild weather with just enough heat to supply the building losses, maintaining a more healthful atmosphere and greater operating economy.

2. Simplicity of control, minimum of devices and less elaborate piping makes these systems economical to operate and lowers maintenance expense.

3. Permits zoning of buildings for various heating and weather requirements with resultant fuel saving.







In the design and operation of the orifice type system, reference to the accompanying diagrams, indicates recognition of the following facts:

1. The most valuable heat obtainable from the steam in a radiator is the latent heat. A heating system should therefore operate at approximately 100 per cent thermal efficiency, as compared with modern power plants which have only 20 per cent economy because of loss of this latent heat.
2. If the steam supply to a radiator is reduced it will be observed that the upper portions of the radiator will be hot and the lower portions cold. It is therefore often unprofitable to pump the return water long distances back to the boilers as there is no appreciable heat left.
3. When the steam flows into the top of a radiator, the air being heavier, if permitted to freely do so, will naturally flow out of the bottom and no unusual device is required to make it do so.
4. With the orifice system of distribution, the supply of steam to the radiators is so easily controlled that return valves, or radiator traps, are not essential.
5. If the return pipes are either vertical or have a slight uniform pitch downward with the flow, it is not necessary to go to the expense of pumping a vacuum on the return piping. An ordinary return water receiver with open vent pipe to let the air out and a pump to put the water back into the boilers are all that are necessary.
6. The modern method of selecting steam supply pipe sizes is to keep the frictional resistance or pressure drop in the steam mains within certain percentage limits of flow to the more remote radiation.

TALLMADGE SERVICE

Corrects operation in any type or size of plant
Power—Process—Heating
Practical Surveys and Reports by trained technical men.

Johnson Service Company

Milwaukee, Wis.

BRANCHES

GREENSBORO, N. C., Daily News Building, P. O. Box No. 617

ALBANY, N. Y., 4 Ramsey Place
ATLANTA, GA., 210 Bona Allen Building
BALTIMORE, MD., 911 Cathedral Street
BOSTON, MASS., 31 Waltham Street
BUFFALO, N. Y., 503 Franklin Street
DALLAS, TEXAS, 2505 Commerce Street
CHICAGO, ILL., 1355 W. Washington Blvd.
CINCINNATI, OHIO, 1113 Race Street
CLEVELAND, OHIO, 2142 East 19th Street
DENVER, COLO., 1230 California Street
DES MOINES, IOWA, 1118 Grand Avenue
DETROIT, MICH., 427 Brainard Street
INDIANAPOLIS, IND., 312 E. Ohio Street
KANSAS CITY, MO., 411 East Tenth Street
MILWAUKEE, WIS., 149-159 E. Michigan Street
LOS ANGELES, CAL., 428 Union Insurance Building
MINNEAPOLIS, MINN., 922 Second Ave., South
NEW YORK, N. Y., 28 East Twenty-ninth Street
PHILADELPHIA, PA., 12th and Cambria Streets
PITTSBURGH, PA., 10 E. North Diamond St., N. S.
PORTLAND, ORE., 404 Postal Building
SALT LAKE CITY, UTAH, 610 McIntyre Bldg.
SAN FRANCISCO, CAL., 814 Rialto Building
SEATTLE, WASH., 473 Colman Building
ST. LOUIS, MO., 2328 Locust Street

CANADIAN REPRESENTATIVE

Johnson Temperature Regulating Company of Canada, Limited

OFFICES

CALGARY, ALTA, 605 Second Street, West
VANCOUVER, B. C., 550-6th Avenue, West
TORONTO, ONT., 100 Adelaide Street, East
WINNIPEG, MAN., 259-261 Stanley Street

Products and Services

ENGINEERS and CONTRACTORS for the CONTROL of TEMPERATURE or HUMIDITY for any purpose and over every range used in manufacturing purposes or buildings, furnishing and installing:

Temperature Controlling Apparatus for any and all kinds of heating and ventilating systems.

Temperature Controlling Apparatus for any industrial process requiring the medium of heat.

Control of Humidity in industrial processes requiring artificial humidity.

Temperature Control of hot water tanks and all liquids.

Control of Temperatures of refrigerating and cold storage plants.

Thermostat Control of electric motors on automatic refrigerating machines.

Manufacturers of THERMOSTATS and Other APPARATUS for the CONTROL of TEMPERATURE and HUMIDITY, including:

Pneumatic Room and Insertion Thermostats and Humidostats.

Electric Room and Insertion Thermostats and Humidostats.

"Sylphon" Metal Diaphragm Valves.

High Grade Dampers of all Shapes and sizes.

Low Pressure, Limited Capacity, Electric Air Compressors.

Low Pressure, Limited Capacity, Hydraulic Air Compressors.

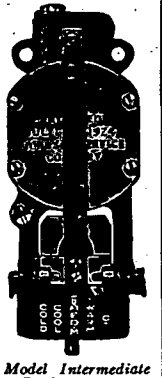
Air and Water Reducing Valves.

Pneumatic Switches or Push Buttons.

Johnson All-Metal Thermostats

Every Johnson Thermostat is ALL-METAL throughout, having no soft or hard rubber parts to deteriorate and become inoperative. Every thermostat exquisitely made and thoroughly tested for accuracy, efficiency and durability.

Johnson Intermediate or Graduated Action Thermostat



Model Intermediate Gradual Acting Thermostat

This thermostat has an all-metal movement, giving true graduated motion to mixing dampers or valves. It holds the valves and dampers in an intermediate position to maintain the temperature of the room accurately within one degree above or below the setting of the thermostats. This thermostat is best suited for all systems of heating and ventilating except single pipe gravity steam systems. The Johnson positive movement is manufactured for use in connection with single pipe gravity steam systems.

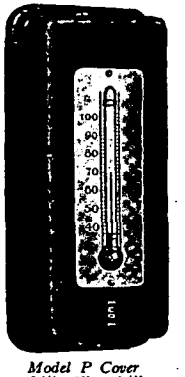
Johnson Compound Thermostat

The Johnson All-Metal Compound Thermostat combines the feature of both the Positive and Intermediate and is applicable for control of valves or dampers where certain units are to be operated positively and others intermediately at an interval of a few degrees in temperature.

Johnson Dual or Two-Temperature Thermostat

The Dual, or two-temperature Thermostat provides for a daytime temperature (usually 70°) and a night-time temperature (35° to 50°), as desired, for all or some of the rooms in a building, simply by the manipulation of a single push button by the engineer or other person in authority. It is an all-metal thermostat and operates valves and dampers with a gradual motion holding them in an intermediate position to maintain the temperature of the room accurately within one degree above or below the setting of the thermostat. It is a factor for the greatest economy in school buildings, a number of rooms of which are occupied at night as well as day, and for any buildings in which some of the rooms are occupied only at certain times, such as churches, auditoriums, masonic temples and lodges.

Thermostat Covers



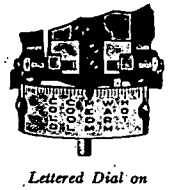
Model P Cover 4¾" x 2" x 1¼"

The covers which conceal the thermostat proper are small, inconspicuous and very neat in design and workmanship.

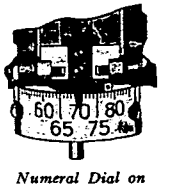
There are two distinct styles: one called the **R** type and one called the **P** type.

The **R** type is a die-casting, very beautifully designed and used generally in residences and other handsomely decorated buildings.

The **P** type is a pressed metal cover, very finely finished but not as ornamental and artistic as the **R** cover, and used more generally in schools, office buildings, hospitals and places where simple and neat design is desired rather than artistic and ornamental.



Lettered Dial on Thermostat



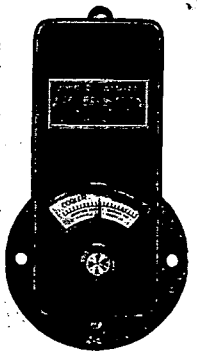
Numeral Dial on Thermostat

Johnson Pneumatic Insertion Thermostat

Designed to control temperatures within closed air chambers or ducts. The body of thermostat is a dust-proof case containing the two working parts and extending outside the chamber.

The thermostat is a graduated acting intermediate thermostat holding the valves and dampers in an intermediate position to maintain the temperature within one degree above or below the setting of the thermostat.

Applications

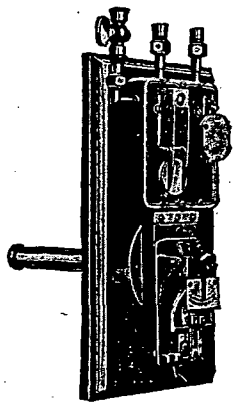


Pneumatic Insertion Thermostat

Adaptable for use in bake ovens for enamels, japans, etc.; drying rooms for paints, varnishes, patent leather, etc.; storage rooms for tobacco, rubber or similar goods; sterilizers or pasteurizers; cold storage rooms, fur vaults, etc.; refrigerator machine control; humidity control for air washers; flue gas temperature control; hot blast heating plants; combination tempered ventilation and hot blast systems; greenhouses, turkish bath rooms, etc.; tempered ventilation for buildings.

Multiple Insertion Thermostat

Similar to the insertion duct thermostat, excepting that one multiple thermostat takes the place of a number of separate duct thermostats set for different temperatures. The 4-point multiple thermostat shown will operate four separate diaphragm valves at as many different temperatures. It has become very popular with heating engineers for the control of heating and tempering coils where it is desired to have these coils turn on at different temperatures. It is a gradual acting thermostat holding the valves and dampers in an intermediate position to maintain the temperature of the room accurately within one degree above or below any desired point.



Multiple Insertion Thermostat

Tank Thermostat

Designed for insertion through 1-in. tapped hole in tank and controlling, in the case of hot water tanks, a diaphragm valve on the supply pipe to the steam coils in the tank. It can be used to control the temperature of any liquid, either hot or cold. It is especially adaptable for controlling the temperature of water in hot water heating plants by its control of the boiler draft doors.

Humidostats and Humidifiers

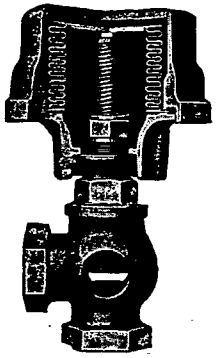
The humidostat automatically controls the supply of moisture delivered to the air by a humidifier and maintains a constant percentage of relative humidity. It operates a diaphragm valve on the steam coils in the pan humidifier. The pan is provided with float box to maintain constant water level and is located in the ventilating air duct leading throughout the building. Steam jet and water spray types of humidifiers are also furnished.

Humidity Control

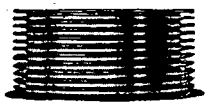
The supplying of moisture to the heated air in buildings and the automatic control of the percentage of moisture in this air are recognized by authorities to be as important as maintaining proper temperatures.

"Sylphon" Metal Bellows Valves

This valve having an indestructible 1-piece metal bellows, is permanent and requires no repairs. Its value for the control of steam is obvious and particularly so in connection with steam coils, radiators in wall boxes where excessive heat would destroy rubber diaphragms.



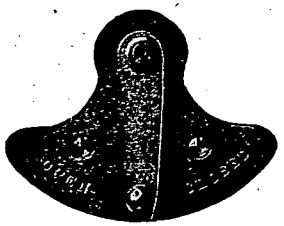
Sylphon Metal Bellows Valve



Sylphon Metal Bellows

Pneumatic Switch Control

Remote valve and damper control plays, by means of our pneumatic switches, a very important part in the economical operation of the modern heating plant especially in schools. It saves the janitor's time for other duties, and makes it possible to accomplish results in the operation of the heating plant which can not be obtained in any other way. It makes it easy to operate the fresh air, return air and vent dampers, with the corresponding assurance that these dampers will be economically operated as intended by the heating engineer.



Pneumatic Switch

The following types of pneumatic switches for different purposes and different conditions are made:

Lever Handle Switch,

Push Button Switch,

Indicating Switch, to open and close dampers partially as desired.

Electro Pneumatic Switch, to open and close dampers automatically—with the starting and stopping of fan motors.

How to Specify

Furnish and install the Johnson System of Automatic Temperature Regulation, to be erected and assembled by trained mechanics employed by the manufacturer, The Johnson Service Company, in all rooms marked "T C" and as hereinafter specified. The system shall be complete consisting of all necessary thermostats, valves, dampers, air compressors, pipe and fittings, and any special apparatus or fittings required.

THERMOSTATS—Install model graduated action all-metal thermostats in proper locations as called for in the specifications or indicated on the plans. Each thermostat shall have an ornamental metal front equipped with an accurate thermometer and be finished to match the hardware of the room or otherwise as directed by the architect. The type of front is to be selected from various patterns offered by the manufacturer. The thermostat is to be mounted securely on a bakelite insulator. Thermostats shall operate the valves or dampers with a gradual motion holding them in intermediate position to maintain the temperature of the room accurately within one degree above or below the setting of the thermostat. Thermostats for the control of ventilating systems shall be of the inserted type having the sensitive element exposed to the heated air and the mechanism in an accessible place, but shall be of metal and operate with the same graduated action as do the wall thermostats or if the DUAL system is desired—

Install DUAL graduated action all-metal thermostats in proper locations as called for in the specifications or indicated on the plans. Each thermostat shall have an ornamental metal front equipped with an accurate thermometer and be finished

to match the hardware of the room or otherwise as directed by the architect. The thermostat is to be mounted securely on a bakelite insulator. Thermostats shall operate the valves or dampers with a gradual motion holding them in intermediate position to maintain the temperature of the room accurately within one degree above or below the setting of the thermostat. The dual thermostats shall be arranged to produce several results as follows: They shall operate at the constant temperature for which they are set during the day or occupied time. It shall be possible to reset the thermostats to a lower night or unoccupied period temperature by the single action of manually operating an air switch, or automatically by means of a clock set to act at a designated time—and it shall be possible to reset them at day temperature in the same manner. (Specify whether or not the clock is desired). It shall be possible to set any one thermostat or any number of thermostats for a constant continuous temperature, night and day, so that the operation of the air switch or of the clock will not change the temperature setting of the thermostat. It shall be possible, by pressing a button on the face of the thermostat, to reset any thermostat for the day time temperature while the balance of the thermostats remain set at the night time temperature.

Provide Johnson Humidostat and (perforated type humidifier) or (copper pan humidifier).

VALVES—Provide sylphon seamless metal bellows valves for each radiator or coil of the size and style required by the heating plans and specifications. Each valve is to be provided with a genuine Jenkins disc for steam control and bronze disc for hot water system. Exposed radiator valves to be nickel-plated finish with polished trimmings. All other valves to be plain finish. All valves to be delivered to the heating contractor who will set in place in risers or run-outs.

DAMPERS—All dampers required for the proper operation of this system as hereinafter specified are to be provided by the heat regulating contractor. These dampers are to be constructed of heavy black iron frames, galvanized blades of proper weight with brass bearings and operated by Johnson sylphon damper motors. All by-pass dampers, fresh air intake, foul air exit dampers, and return air dampers, are to be of the louver type if conditions require. Double mixing dampers are to be of the single blade type so constructed that the blades will not restrict the total flow of air through both openings of the damper.

AIR COMPRESSOR—The air compressor shall be of the electric type and shall be complete with all necessary tanks, gauges, filters, valves, automatic control appliances, lubricators, etc. This compressor shall be of ample capacity and should maintain automatically the desired air pressure for the successful operation of the system with an ideal period at least equal to the operating period. The compressor shall be mounted on a suitable base and be located where directed by the architect. Electric connection to the compressor is covered in electric specifications.

NOTE.—If electricity is not available, a belted hydraulic or steam compressor should be specified.

PIPING—The air distribution system shall be of galvanized steel standard air piping, of proper size planned to supply the requisite amount of air. The mains are not to be less than ⅜ in. pipe and the branches from the thermostats to the valves are to be of ⅛ in. pipe. All pipe shall be thoroughly cleaned and reamed before installation and the whole air piping system shall be held practically tight under an air pressure of 30 lb. per square inch. In finished portions of buildings, piping shall be concealed except in short runs of pipe from the floor or wall to the radiator or damper motors.

GUARANTEE—The entire system is to be complete in every respect and guaranteed by the Company against original defects in workmanship and material for a period of one year, from date of first operation. Thermostats are to be guaranteed to operate the valves in such manner as to maintain the temperature within one degree above or below any desired point providing there is sufficient heat medium and there is no outside uncontrolled source of heat.

Contracting

This company contracts to furnish and install in complete working order the Johnson System of Temperature Control, including thermostats, valves, piping, etc., and gives annual inspection and prompt service to all plants constantly.

National Regulator Co.

Factory and General Offices: 2311 Knox Avenue, **Chicago, Ill.**

TRADE METAPHRAM MARK

MANUFACTURERS OF: National System of Heat Regulation; "Metaphram" Diaphragms; "Metaphram" Damper Regulators for low pressure and hot water boilers; National Humidity Controllers; National Dampers; A-Jacks High Pressure Steam Damper Regulators; National Cam Valves.

National Heat Regulation—National Systems of heat regulation obtain the best possible results in a simple, direct manner, avoiding complicated piping and intricate valve arrangements.

In the National System the control of valves and dampers centers in the adjustable, dust-proof National Thermostat mounted on the wall of the room to be controlled. Thermostatic action of the sensitive, imperishable hard rubber element opens and closes the leak port of the pneumatic system connected to National Metaphram Valves on radiators or National Metaphram Motors on dampers.

The National System provides for gradual control in its most successful form, together with any combination of remote control suitable for the building under consideration. Engineering assistance in plan and layout will be rendered on request, without obligation.

National "Metaphrams"—These are self-collapsing metal diaphragm units designed and patented by this Company for the specific purpose of operating valves and dampers. The sections are constructed of high grade spring brass, which is not spun or heated in the manufacturing process, and so retains all its resiliency and strength. These diaphragms are assembled by means of finely threaded integral studs. Compressed air is applied inside the "Metaphram" and affects so large a surface that maximum power is attained with a minimum of travel.

"Metaphrams" are regularly made in sizes from 2 in. to 10 in. Correspondence is invited from engineers regarding special Metaphram assemblies.

National Dampers—(Round, Double or Louvre Types). National Dampers are operated by Metaphram Motors, and are successful under the most difficult conditions. They are made in our own shops and Metaphram motors are fitted and tested to each damper before shipment.

National Dampers may be controlled by thermostats, remote control switches or by electric-pneumatic valves operated by starting or stopping of ventilating fan motors.

Metaphram Steam Boiler Damper Regulators—A complete line of low pressure steam boiler damper regulators employing "Metaphram" Diaphragms is manufactured to supply the right regulator for every condition and meet the varying requirements of steam boilers.

The Type-F Regulator for hot water boilers and domestic water heaters is a sensitive and positive devise that accurately and continuously apportions the draft required to maintain a given temperature.

Type	Size In.	List Price F.o.b., Chicago
A-Junior	4	$12.00
A	4	15.00
B	5½	18.00
C	7	20.00
D	10	27.00
F	2	18.00

Metaphram Furnace Regulator—The highly successful principles of metaphram Boiler Regulators have been adapted to a simple warm air furnace regulator, easily installed in any return air furnace, offering automatic temperature control without resource to electric or spring wound motors, intricate valves or room thermostat connections.

Complete details will be mailed on request.

Metabar Furnace Fuse—A fusible link which couples into the chain controls of draft and check dampers through a hot air riser. If furnace overheats to 250 deg. (through neglect of hand controls or failure of automatic control), this link melts, closing draft and opening check damper. It is a positive protection against the dangers of overheated furnaces.

THE POWERS REGULATOR CO.

Over 35 years of specialization in temperature control

General Offices and Factory—2719 GREENVIEW AVENUE, CHICAGO, ILL.

General Eastern Offices—137 EAST 46th STREET, NEW YORK CITY

THE CANADIAN POWERS REGULATOR CO., LTD., TORONTO, ONT.

List of Branch Offices of The Powers Regulator Co.

ATLANTA, GA.
BALTIMORE, MD.
BIRMINGHAM, ALA.
BOSTON, MASS.
BUFFALO, N. Y.
BUTTE, MONT.
CHATTANOOGA, TENN.
CINCINNATI, OHIO
CLEVELAND, OHIO
DENVER, COLO.
DETROIT, MICH.
EL PASO, TEXAS
HOUSTON, TEXAS
INDIANAPOLIS, IND.
KANSAS CITY, MO.
LOS ANGELES, CALIF.
LOUISVILLE, KY.
MILWAUKEE, WIS.
MINNEAPOLIS, MINN.
NASHVILLE, TENN.
NEW ORLEANS, LA.
PHILADELPHIA, PA.
PITTSBURGH, PA.
ROCHESTER, N. Y.
SALT LAKE CITY, UTAH
SAN FRANCISCO, CALIF.
SEATTLE, WASH.
ST. LOUIS, MO.

CALGARY
HALIFAX
MONTREAL
VANCOUVER
WINNIPEG

Products

Automatic Temperature Controlling Systems, applying them, under the supervision of Powers engineers, to the heating plants, new or old, in residences, offices, factories, schools, institutions, and to any other conditions of artificial heating where uniform temperature is desired.

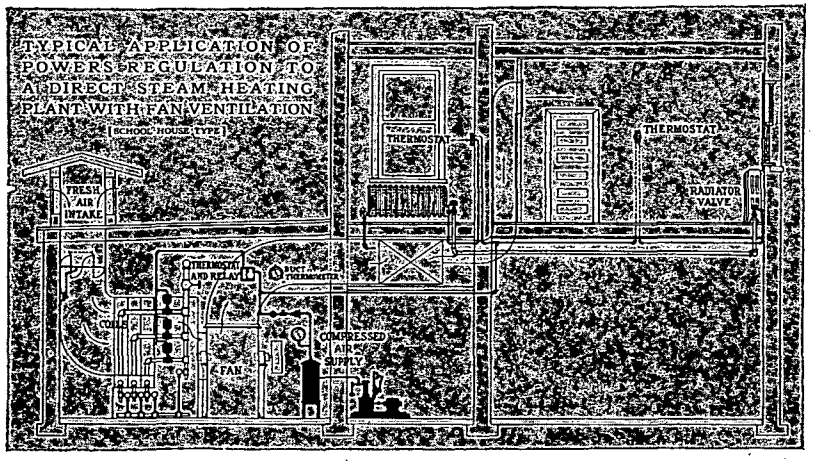
Automatic Regulators for ACCURATELY controlling temperature of Liquids, Gases and Air, Pressure Reducing Valves, High Pressure Steam Traps, Humidity Control Devices, Shower Mixing Valves, Etc.

Temperature Controlling Appliances

Powers thermostats are accurate in their working and will maintain their adjustment. They are of the vapor disc type, exclusive with Powers regulators, and are not thrown out of adjustment by extremes of temperature or long disuse. For over 35 years the accurate control obtained by this method has been the standard of thermostatic control by which all other methods are measured. In design, Powers thermostats are second to none in beauty and perfection of finish; in size, as small as is consistent with the reliability so necessary in such instruments; in operation, sure, with gradual or positive action, as conditions require.

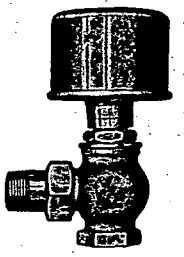
Diaphragm radiator valves, diaphragm motors, mixing dampers and other equipment are especially rugged in construction dependable and durable; built regardless of expense, for efficiency and long service.

Motive power used in these systems is compressed air. The company builds its own air compressors, operated by steam, or electricity, and characterized by their reliability, noiseless operation, perfect control and long life.





Powers Type D Thermostat



The Powers All-Metal Radiator Valve

Installations

Installations of Powers systems are invariably made by the company. At each branch office is maintained a competent engineering and erecting force, sparing no expense to maintain the highest efficiency. Powers special devices, however, are easily installed by any engineer or contractor.

Prices

Price for Powers regulation covers the system installed complete, and is only named after a careful study of the requirements. Our price is not lowest, but no other system will be found so efficient and economical. Customers are served with the sole aim of getting results for them; and experience shows that **satisfactory service from a temperature controlling system is of much more importance than its first cost.**

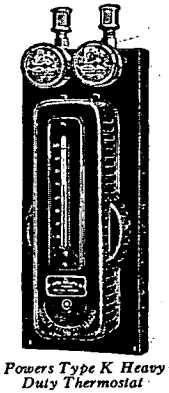
Specifications

Heating systems, and the requirements for temperature control, vary widely in detail. Much of the dissatisfaction experienced with some systems of temperature regulation is due to the attempt to force a ready-made inflexible system or device to meet special requirements, taking no account of the conditions peculiar to the situation to be treated.

For these reasons we believe special study should be given each case. We shall be glad to submit to any Architect or Engineer a detailed Specification, accompanied by a guaranteed price, to cover complete system of temperature control installed, the price to hold if specification is used. This guarantees full protection to the client against advantage being taken of a close specification. This company will gladly collaborate with Architect or Engineer in preliminary plans. As specialists in temperature control, The Powers Regulator Company has unusual facilities for solving problems in this particular field.

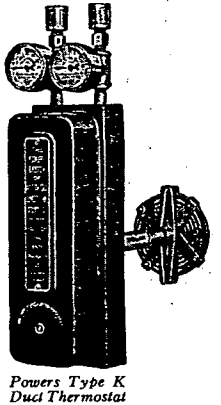
Catalogs

Engineers, Architects, and others who wish further information regarding the Powers System, will find it in the following books: *Elimination of Heat Waste* shows applications in schools, churches, and other public buildings, residences, etc.; *Shop and Office Temperatures* shows applications in shops, offices and workrooms, also presents proof of fuel savings and increased production due to its use.



Powers Type K Heavy Duty Thermostat

Write for Bulletin No. 251



Powers Type K Duct Thermostat



Powers Hygrostat for Humidity Control

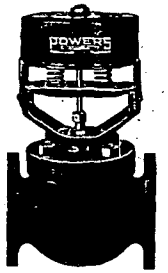
POWERS ALL-METAL DIAPHRAGM VALVES



Low Pressure All-Metal Valve



High Pressure All-Metal Valve



L. P. Iron Body Valve Flanged



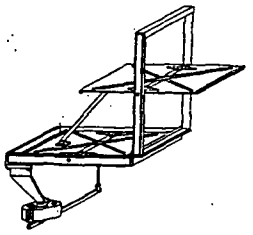
Brine Control All-Metal Valve



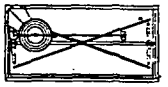
Three-Way All-Metal Valve

Write for Bulletin No. 244

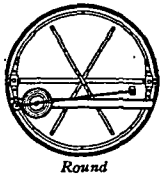
POWERS DAMPERS



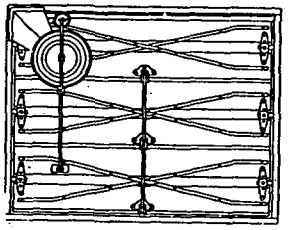
Mixing



Single



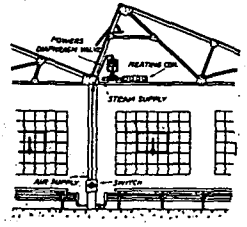
Round



Louver

Write for Bulletin No. 244

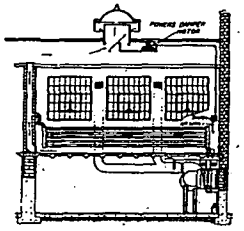
POWERS PNEUMATIC SWITCH FOR REMOTE CONTROL

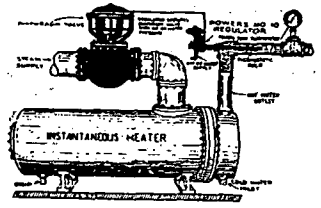


of Diaphragm Valves and Dampers



Write for Bulletin No. 257

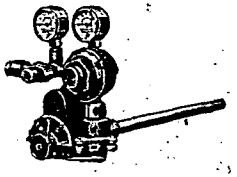




NO. 10 REGULATOR

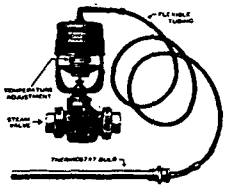
operated by Compressed Air or Water Pressure

Write for Bulletin No. 216

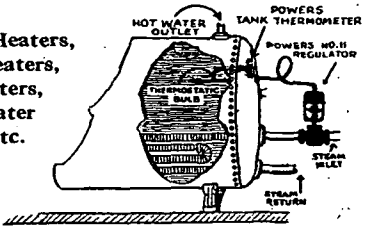


POWERS SELF OPERATING REGULATORS

POWERS NO. 11 REGULATOR

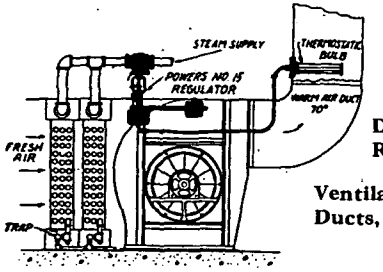


For Hot Water Heaters, Feed Water Heaters, Fuel Oil Heaters, Drinking Water Systems, Etc.



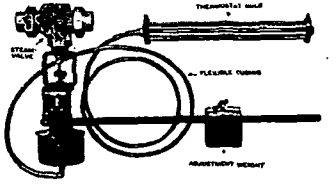
Write for Bulletin No. 229

POWERS NO. 15 REGULATOR



For Drying Rooms

Ventilating Ducts, Etc.



Write for Bulletin No. 238

POWERS NO. 16 REGULATOR



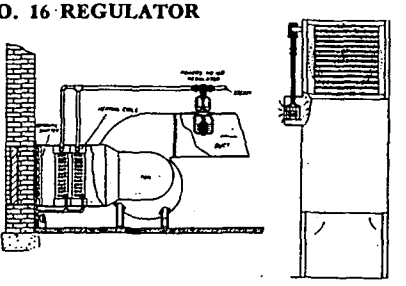
Style A



Style B

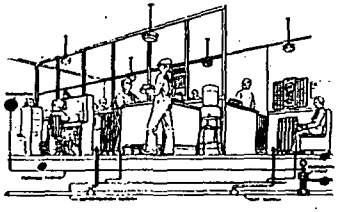
For Unit Heaters

Ventilating Ducts, Brine Coil Control, Etc.



Write for Bulletin No. 246

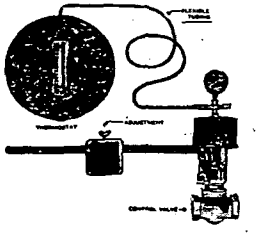
POWERS NO. 18 REGULATOR



Installed on direct heating system in an office

For Storage Rooms Offices and Factories

Write for Bulletin No. 245



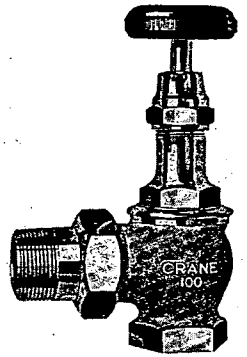
CRANE CO.

Manufacturers of Valves, Fittings, Fabricated Piping, Steam Specialties, Plumbing and Heating Materials

836 S. Michigan Avenue **Chicago, Ill.**

Branches in All Principal Cities

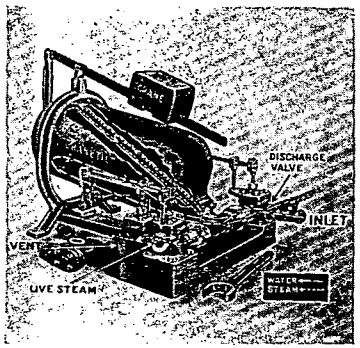
Write for catalogues and full information about any materials in which you are interested



Radiator Valve No. 220

Sizes ½ to 2 inch, incl.

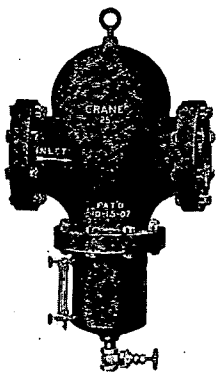
Brass. For steam or vacuum systems. Self-adjusting packed stuffing box. Crane renewable disc.



Cranetill 3-Valve Trap Series No. 100

Sizes ½ to 3 inch, incl.

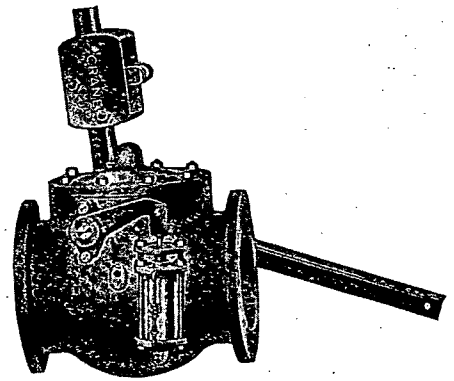
For lifting condensation to a higher point, for vacuum or pressure lines, for lines of varying pressure, for draining oil separator, for metering.



Oil Separator No. 01

Sizes ½ to 10 inch, incl.

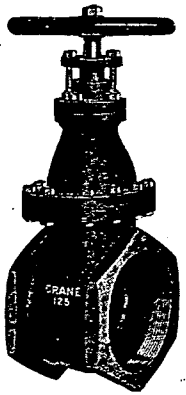
Cast iron. For elimination of oil and water from exhaust or vacuum lines. Larger sizes and vertical pattern also available.



Relief Valve No. 415H

Sizes 4 to 36 inch, incl.

Back pressure and exhaust. Iron body, brass mounted. For condensing or non-condensing engines. Dashpot cushions the disc and prevents pound or hammer. Also available in vertical and angle type.



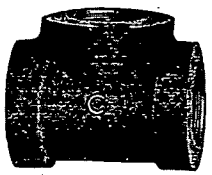
Wedge Gate Valve No. 460

Standard, non-rising stem. Iron body, brass trimmings. Screwed or flanged.



Cast Iron Elbow

Standard, screwed. For steam working pressures to 125 lbs. and water working pressures to 175 lbs.



Cast Iron Tee

Standard, screwed. For steam working pressures to 125 lbs. and water working pressures to 175 lbs.



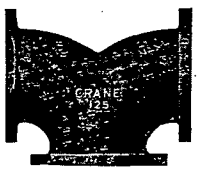
Wedge Gate Valve No. 438

Standard, brass. Non-rising stem. With gland in stuffing box.



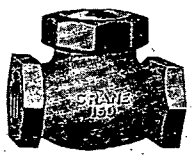
Elbow No. 525

Standard, cast iron. Flanged. For steam working pressures to 125 lbs.



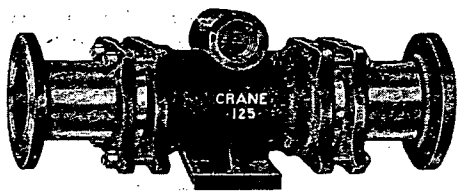
Elbow No. 538

Standard, cast iron. Double branch. Flanged. For steam working pressures to 125 lbs.



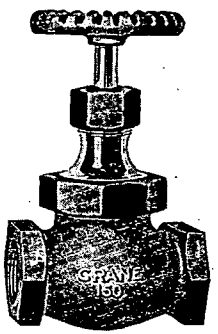
Check Valve No. 27

Brass. Horizontal or angle patterns. Crane renewable disc. Union bonnet.



Double Expansion Joint No. 409

Iron body, brass sleeves. Flanged. Furnished with screwed ends when so specified. For steam working pressures up to 125 lbs.



Globe Valve No. 7

Brass. Many purpose valve. Crane renewable disc. Union bonnet.

The Direct Control Valve Company

332 South Michigan Boulevard

Chicago, Illinois

Branch Offices

New York City
101 Park Avenue

Newark, New Jersey
972 Broad Street

Rochester, New York
306 Laburnum Crescent

Philadelphia, Pa.
1234 Callowhill Street

Pittsburgh, Pa.
1007 Diamond Bank Bldg.

Milwaukee, Wis.
Chase and Burnell Streets

Waterloo, Iowa
111 Highland Boulevard

Oklahoma City, Oklahoma
120 East Main Street

Detroit, Michigan
2051 West Lafayette Boulevard

St. Louis, Mo.
Tower Building

Atlanta, Ga.
Red Rock Bldg.

Cleveland, Ohio
1630 Lewis Drive

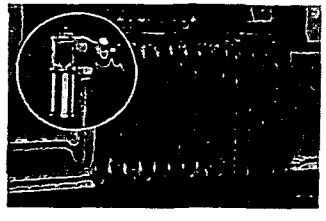
Boston, Mass.
131 State Street

San Francisco, Calif.
307 Minna Street

Minneapolis, Minn.
Plymouth Building

DIRECT CONTROL VALVE

It is a thermostatically operated, hydraulic, quick opening, packless radiator valve, controlling the steam to the radiator so as to automatically maintain room temperature at any required degree.

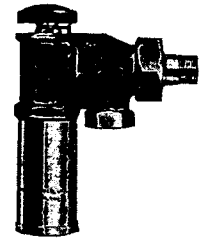


Self Contained Unit

The Direct Control Valve is a tried and perfected method of individual radiator control. It is a complete, self contained unit requiring no outside attachments or power of any kind. It is as easily installed as a hand valve. *It costs only a fraction* of the usual temperature control system. It automatically regulates the amount of steam to the radiator. The saving in fuel alone usually repays its cost in about 3 years.

It may be applied to any building, new or old, which is equipped with a two pipe heating system—vacuum, vapor, or atmospheric steam.

The degree of temperature at which the room is to be maintained may be controlled by the occupant of the room. Or the valve can be equipped with a lock to be operated only by the building operator.



Advantages

Reduced Fuel Cost—Maintains constant, healthful temperature with large savings in steam and fuel. *The savings in fuel alone return complete installation costs together with interest on the investment in about 3 years.*

Low Maintenance Cost—There is practically no maintenance cost. The Direct Control Valve is a self contained unit requiring no outside accessories or attachments, no complicated piping systems, no delicate wall mounted thermostats. *The First Cost is the Last Cost.*

THE DIRECT CONTROL VALVE COMPANY

Low Initial Cost—It requires no more labor installation cost than an ordinary hand valve. The simplicity of design and the sturdy construction assures uninterrupted temperature control within the prescribed control limits with practically no upkeep costs. The valve is of all metal construction, guaranteed for 3 years, and built to give indefinitely long service.

Description

Thermostatic Unit—The thermostatic unit, 3½ in. long, is ruggedly built to withstand abuse. Utilizes hydraulic pressure for valve operation. Is positive and powerful, fulfilling test of 2500-3000 lbs. per sq. in. The hydraulic pressure is constant and effective. It is unaffected by evaporation or chemical change—once filled and sealed it remains in its original condition developing constantly the necessary power to firmly seat the valve.

Standard Type—Occupies a minimum of space. Height over all 7 in.

Sizes—Furnished in ¾, 1, 1¼, 1½ and 2 in. sizes.

Recessed Radiators—For concealed or recessed radiators, valves can be furnished with extension stems.

Specification

On each radiator, furnish and install a self contained thermostatic radiator valve, designed to control room temperature within one degree above or below a predetermined room temperature.

These values shall be actuated by means of hydraulic thermostat and shall be so arranged that each valve can be shut off by hand or not, as desired.

These valves shall be designed to control at an average room temperature of ..... deg. fahr.

Valves shall be nickel plated finish and shall be of the following sizes:

For radiators up to 80 sq. ft. ¾ in. valve
For radiators 80 to 140 sq. ft. 1 in. valve
For radiators 140 to 250 sq. ft. 1¼ in. valve
For radiators 250 to 350 sq. ft. 1½ in. valve
For radiators 350 sq. ft. and above 2 in. valve

Standard Guarantee

The Direct Control Valve Company guarantees that a Direct Control Valve or Valves, when properly installed on sufficient radiation to properly heat the room, will maintain a room temperature within the limits of 1 deg. fahr. above and 1 deg. fahr. below the point of adjustment.

A Few Notable Recent Installations:

Pittsfield Bldg.
Chicago

Insurance Exchange
Chicago

New York Insurance Bldg.
New York City

Fisher Bldg.
Detroit

Koffers Bldg.
Pittsburgh

Arnold-Constable Bldg.
New York City

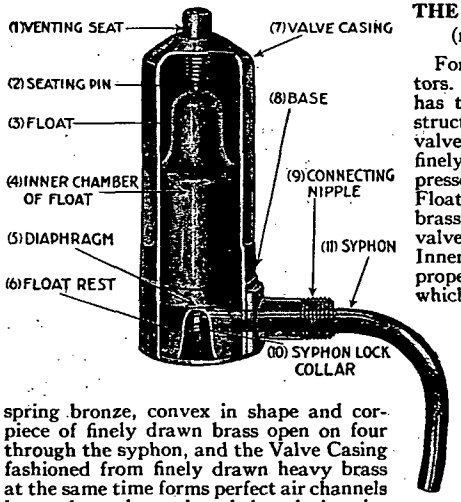
Willoughby Tower
Chicago

Reynolds Tobacco Co., Bldg.
Winston-Salem, N. C.

The Dole Valve Company

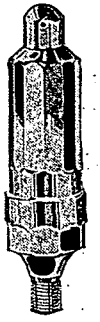
1913-1933 Carroll Avenue, CHICAGO, ILL.

Manufacturers of High Grade Radiator Valves and Brass Specialties



THE DOLE SYPHON AIR VALVE
(non adjustable, automatic)

For venting low pressure steam radiators. Fully guaranteed for five years. It has the Venting Seat (1) of heavy construction, threaded and brazed into the valve casing. The Seating Pin (2) of finely machined hard metal is hydraulically pressed to a perfect radius, while the Float (3) is of light but strong annealed brass, which rises when water enters the valve, positively preventing leakage. The Inner Chamber of Float (4) contains the proper amount of thermostatic liquid which forms a powerful gas when steam comes in contact with the float; thus the diaphragm is expanded and the valve closed against the escape of either steam or water. The Diaphragm (5) is made from special spring bronze, convex in shape and corrugated. The Float Rest (6) is one piece of finely drawn brass open on four sides to permit water to drain through the syphon, and the Valve Casing (7) of beautiful dodecagon design, fashioned from finely drawn heavy brass presents an attractive exterior and at the same time forms perfect air channels inside the valve. The Base (8) of heavy drawn brass threaded on the interior to meet exterior threading on the casing is firmly brazed to insure great strength and durability. The Connecting Nipple (9)—one piece of extra heavy drawn brass has ⅛ in. standard iron pipe thread, which conforms to the requirements of all radiators. A Syphon Lock Collar (10) made from extra heavy brass firmly brazed to the syphon prevents either accidental or intentional removal of the syphon from the valve. (Note, the valve can be removed from the radiator without the syphon becoming detached). The Syphon (11)—one piece of annealed brass tubing, is perfectly formed to fit inside the radiator column. Assembled into the valve free from obstruction, thus preventing interference when the valve is attached to the radiator. Regarding the finish, the entire valve is finely nickel plated, of an artistic design and highly polished. A real "beauty" and it works.



List Price.....$1.50

THE DOLE STRAIGHT SHANK QUICK VENT AIR VALVE

For quick venting the ends of steam mains, specially useful for venting hot water generators and low pressure feed water heaters where a straight shank valve is required. Made from similar material, constructed in like manner and operates on the same principle as the Dole Syphon Air Valve. Made in three sizes—¼ and ⅛ in. List Price **$2.00** and the ¾ in. List Price **$3.00.**

The Fairbanks Company

NEW YORK, N. Y. BOSTON, MASS.
PITTSBURGH, PA. LONDON, ENGLAND

Factory: **Binghamton, N. Y.**

Fairbanks Bronze Globe Valves



Fig. 01

Simple in construction; parts quickly and easily renewed; stuffing box packed with specially moulded vulcabeston ring which is durable and cannot be blown or washed out; valves can be packed under pressure when wide open. Made in sizes ⅛ to 3 in.

Fairbanks Bronze Radiator Valves

Globe and Angle Types

Embody all good points of the Fairbanks Fig. 01 Valve. Furnished with Wood Wheels or lock shield and T handles. Made in sizes ⅛ to 2 in.



Fig. 012

Fairbanks Standard Bronze Gate Valves



Fig. 0205

For general service. Stuffing boxes can be repacked under pressure when wide open. Guides in wedge and ribs in body so fitted as to insure true and easy movement; prevent wedge from touching seats except at point of closing. Made in sizes from ¼ to 3 in.

Fairbanks Bronze Swing Check Valve

As perfect a check valve as ever constructed. Has full area equal to pipe connection and straightway passage. The rotating disc works freely, never sticking on the seat. Made in sizes ¼ to 3 in.

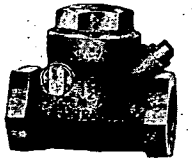


Fig. 0601

Fairbanks Iron Body Valves

Globe and Angle Types with Renewable Vulcabeston Ring Disc



Fig. 0101

Embody the most modern renewable features. Have a raised round seat upon which scale, grip or other sediment will not lodge. Disc Rings will not crack or flake; easily and quickly renewed. Valve so constructed as to eliminate all rattling or tilting when open.

Fairbanks Standard Iron Body Gate Valves

Designed for a maximum steam working pressure of 125 lb. Guides in wedge and ribs in body so finished and fitted as to insure true and easy movement; prevent wedge from touching seats in body, except at point of closing. Made in sizes from 2 to 12 in. Flanged type up to 20 in.



Fig. 0402

Fairbanks Iron Body Swing Check Valves

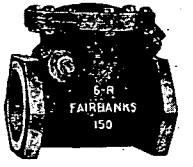


Fig. 0701

Designed with a 45 deg. Angle seat making it possible to use the valve in either a horizontal or a vertical position. Regularly equipped with Bronze Disc; can be furnished with Rubber Disc for water service. Made in sizes 2 to 12 in.

Fairbanks Sphero Ball Valves

An entirely different principle,—designed and built to meet the need of an easily operated, quickly repaired valve. Construction is simple and substantial. Has straight through passageway, renewable seats, interchangeable parts, and is easily opened or closed. Made in sizes from ½ to 8 in.

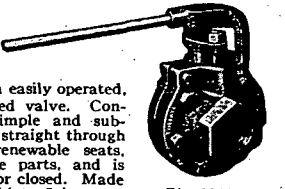


Fig. 0828

Jenkins Bros.

Manufacturers of Valves and Mechanical Rubber Goods

PRINCIPAL STORES AND OFFICES

80 White Street, NEW YORK, N. Y. — 524 Atlantic Avenue, BOSTON, MASS. — 133 North 7th Street, PHILADELPHIA, PA. — 646 Washington Boulevard, CHICAGO, ILL.

FACTORIES IN ELIZABETH, N. J. AND BRIDGEPORT, CONN.

JENKINS BROS., LIMITED

CANADIAN WORKS AND HEAD OFFICE: MONTREAL, QUE., 103 St. Remi Street
LONDON OFFICE: 6 Great Queen Street, Kingsway, W. C. 2

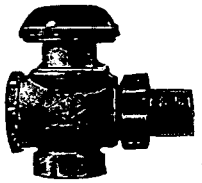


Fig. 700, Jenkins Modulating Valve

PRODUCTS

Jenkins Globe, Angle, Cross, Check, Hose, Blow-Off, Safety and Gate Valves; Radiator Supply Valves; Automatic Radiator Air Valves.

Also, Rapid Action Valves; Steam Traps; Gage Cocks; Marine Valves, Needle Valves—Valve Discs; Jenkins '96 and Jenarco Sheet Packing, Gaskets, Pump Valves; Compressed Asbestos Jointing; and Moncrieff Scotch Gauge Glasses.

Modulating Valve

A notable improvement over present day modulating valves lies in Fig. 700 Jenkins Modulating Valve which has a vertical instead of a horizontal seat, affording these particular advantages:

Foreign matter cannot lodge on seat and prevent tight closing of valve.

Vacuum is under disc holder, which is fitted with Jenkins Rubber Composition Disc, with a tendency to draw disc to the seat. Spring holds disc against seat. Seating and tightness do not depend on threaded spindle that needs to be turned down tight to prevent leakage.

This valve cannot leak around spindle.

Made of bronze, nickel plated, ¾ inch size, suitable for 100 square feet of radiation. The center to end dimensions conform to the recommendations of Heating and Piping Contractors National Association and Manufacturers Standardization Society. Write for Bulletin 105 for complete details.

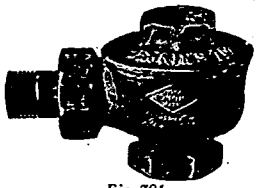


Fig. 701 Jenkins Thermostatic Return Trap

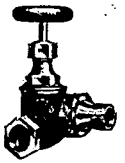


Fig. 180, Bronze Offset Corner, Radiator with Union

RADIATOR VALVES

Regularly furnished with black composition wheels, or, if desired, with bronze, wire or iron wheels. Furnished in the new low bonnet patterns or the regular pattern as supplied for years.

Lock shield valves, to be operated with key, designed to prevent tampering, can be supplied in all the different patterns.

Corner valves are made in two patterns—regular and offset.

Regular styles of finish follow:

Rough body, finished trimmings, No. 1 screwed, No. 6 with union.

Finished and polished all over, No. 2 screwed, No. 7 with union.

Rough body, nickel-plated trimmings, No. 3 screwed, No. 8 with union.

Rough body, nickel-plated all over, No. 4 screwed, No. 9 with union.

Finished and nickel-plated all over, No. 5 screwed, No. 10 with union.

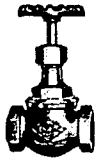


Fig. 106, Bronze Globe, Screwed



Fig. 853 Low Bonnet Radiator Angle, Male Union



Fig. 352, Bronze Swing Check Valve

CATALOG

A catalog of all the Jenkins valves, giving sizes, styles and list prices, mailed on request.

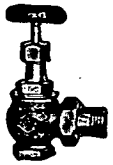


Fig. 168, Radiator Angle, with Union

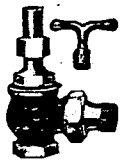


Fig. 170, Bronze Lock Shield Radiator Angle, with Union

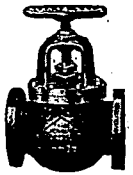


Fig. 142, Iron Body Globe, Flanged

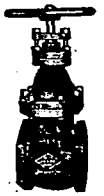


Fig. 326, Iron Body Gate, Screwed



Fig. 370, Bronze Gate, Screwed

New York Air Valve Corporation

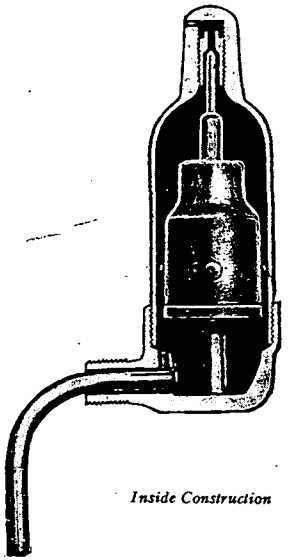
476-478 Broome Street
New York

THE "AIR-OUT" LINE

SYPHON — THERMOSTATIC — NON-ADJUSTABLE

"Air-Out" valves, for eliminating air from steam radiators, operate by the expansion of a phosphor bronze diaphragm, soldered on the bottom of a brass float, containing a volatile liquid. This float is large in size, allowing ample capacity for the necessary pressure to operate the diaphragm.

The seating pin at the top of float is made from nickel silver, as called for in United States Government specifications for Air Valves. Verdigris will not form on nickel silver—corrosion at the vent post is therefore reduced to a minimum.



Inside Construction



We do not use a "stamped out" base. Our bases are heavy bronze castings, in one piece, with no soldered parts to break off.

Made also in straight pattern, threaded ⅛, ¼ and ¾ in. for quick venting of cellar mains and risers.

The best valve money and experience can produce and sold at reasonable prices.

OTHER SPECIALTIES

Carbon Post Automatic Air Valves.
Key and Wood Wheel Air Valves.
Adjustable Floor and Ceiling Plates.
Steam and Altitude Gauges.
Water Gauges.
Pop Safety Valves.

"Air-Out" Valves Guaranteed for Five Years

Marsh Valve Company

Plant and General Offices: DUNKIRK, NEW YORK

General Sales Distributors

Edward T. Hetherington
1709 Sansom Street, Philadelphia, Pa.

United States Radiator Corporation
General Offices, Detroit, Mich.

Taylor-Forbes Company
Canadian Agents, Guelph, Ont.

Appleton & Liptrott, Inc.
1480 Broadway, New York

John W. Mabbs
431 S. Dearborn Street, Chicago, Ill.

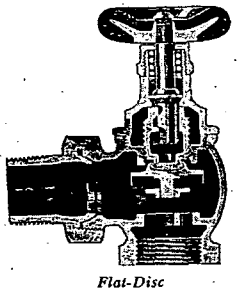
Sarco Company, Inc.
183 Madison Avenue, New York

We specialize on high-grade Radiator Valves and make the largest line of any company in the world.

The re-enforced packless feature of our Packless and Modulated lines both steam and water and the upper seat features of our Union Bonnet, Special and Gate lines are distinctive, scientific, mechanical principles, used with these lines exclusively.

MARSH RE-ENFORCED PACKLESS RADIATOR VALVES

Oval Wheel or Lock Shield



Flat-Disc

All sizes and patterns Globes, Angles Corner and Back Offsets

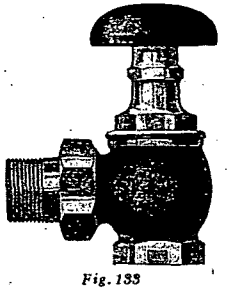


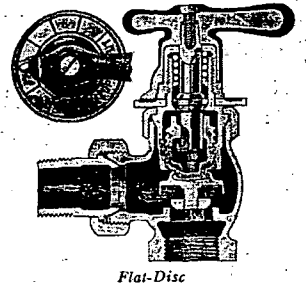
Fig. 133

We call particular attention to the scientific mechanical construction of the Re-enforced Cone Metal Packless Feature of our Modulated and Packless Valves. These are the only Packless Valves in which the Packless feature is re-enforced or in any way protected against leakage due to wear or cracks of so-called Packless parts and are GUARANTEED against wear or defects of Packless construction and leakage through bonnets.

QUICK OPENING

A three-fourths turn will fully open a ¾ in. valve, and from this up to one and one-quarter turns for balance of line through 2 in. These valves, account of low pitch of thread due to large diameter of cylinder, will seal and lock against any pressure.

MARSH RE-ENFORCED MODULATED LEVER HANDLE RADIATOR VALVES



Flat-Disc

These Valves may be had with Oval Wheel in place of Lever Handle same as Fig. 147

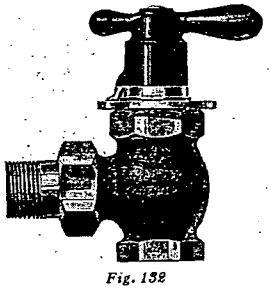
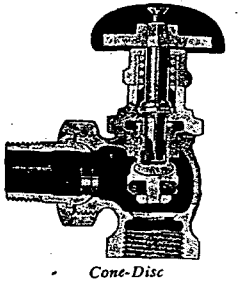


Fig. 132

The Modulation or Graduation is accomplished by a cone disc nut, regulating volume of steam, according to pressure, until indicator registers valve about two-thirds open, when the further turning of lever handle until indicator registers open, will give full valve capacity; a feature of material value in a valve in which volume or capacity for modulating purposes is choked down, and to meet extreme weather conditions, full pipe capacity is required.

MARSH RE-ENFORCED PACKLESS CONE DISC RADIATOR VALVES

Oval Wheel or Lock Shield



Cone-Disc

These Discs will not crack or leak through valve seat.

No clogging or water hammer from return condensation

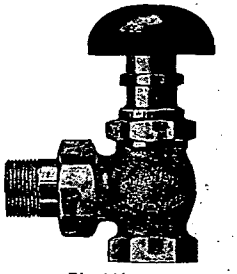
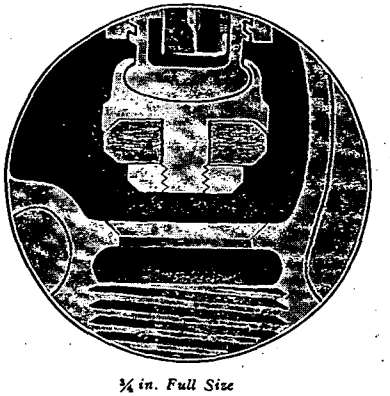


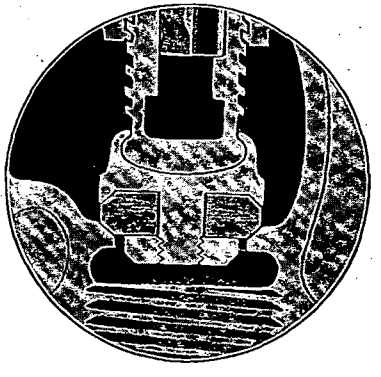
Fig. 141

Marsh Cone Discs are without question one of the greatest improvements in radiator valve construction in the past fifty years or since the composition disc replaced the old style metal-to-metal disc and seat.

This Cone Disc construction combined with the Marsh Re-enforced Packless Feature is the last word in completing radiator valve maximum efficiency at popular price, all of which will check 100 per cent true upon investigation.



¾ in. Full Size



Positive Seal

The above views showing cone disc and beveled seat are to actual size of a ¾ in. valve and are made to full size to show the following advantages of this construction over the old style flat disc and seat:

First: Through design of disc and protection afforded from disc nut covering under surface they will not warp and crack as will a flat disc which overhangs valve seat.

Second: The compression is at right angles to face of seat, forcing disc compound inward to center, making disc more compact and harder instead of scoring and extruding over seat, opening cracks or seams if any, as with a flat disc.

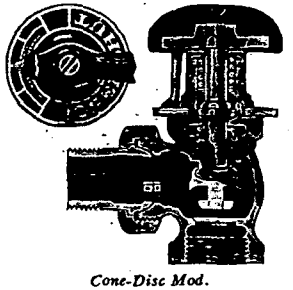
Third: While the life of these cone discs because of construction, as proven by tests, is three to five times the life of a flat disc, and a CRACKED DISC IS IMPOSSIBLE, the matter of exchange if desired is very simple, as to remove disc nut the disc will drop from disc-holder, while with a flat disc it must be dug out, often destroying disc-holder. Further, these cone discs are reversible and can be turned over or replaced with new at the same cost as for a flat disc.

Fourth: The beveled seat is low in valve body, giving complete drainage and will wash free from sand or scale in system, positively providing against leakage through scale or grit imbedding in disc AS IS COMMON with a raised flat seat and flat disc construction.

Fifth: Through this low beveled seat, to return condensation through valve for a one-pipe system, the flow will hold to the outer wall leaving center of valve throat and pipe free rather than shoot out over a raised seat to the center of pipe as is common with a heavy flow over a flat seat, clogging flow of steam, causing hammer or pounding of system.

The foregoing are all, each and every one, practical points which will prove out in test and practice.

MARSH RE-ENFORCED MODULATED CONE DISC RADIATOR VALVES



Cone-Disc Mod.

Oval Wheel, Lever Handle or Lock Shield

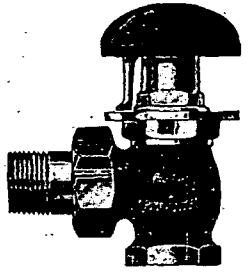


Fig. 147

The Modulation feature of our Cone Disc Line is the same as with our union bonnet flat disc Fig. 132.

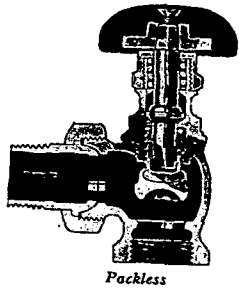
Our Cone Disc Modulated valves unless otherwise ordered are fitted with Oval Wheel. When Lever Handle is preferred, Fig. No. is 148.

With our Oval Wheel Handle user has the same dial and indicator control as with Lever handle and a much stronger and more serviceable CONSTRUCTION than is possible with a Wood wheel as this composition won't break or split as will wood.

Further, this wheel is removable and interchangeable with our Lever handle, effecting a material advantage to customer in matter of convenience of changing from one to the other on job if for any reason change is desired.

MARSH RE-ENFORCED PACKLESS WATER RADIATOR VALVES

Oval Wheel or Lock Shield



Packless

A Genuine Packless Water Valve Guaranteed to hold any pressure required for forced circulation

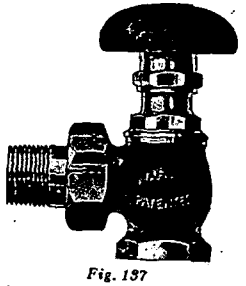


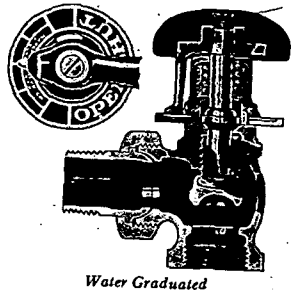
Fig. 137

Marsh re-enforced packless Hot Water Radiator Valves are not only a boon but the answer to hot water heating problems, permitting the same ease of operation and complete temperature control as with steam.

These hot water valves are quick opening, can be operated—opened and closed—with perfect ease by a child and will not stick or leak.

They will hold high pressure suitable for forced circulation up to any pressure radiation will stand, and the cost is nominal.

MARSH RE-ENFORCED GRADUATED WATER RADIATOR VALVES



Water Graduated

Oval Wheel, Lever Handle or Lock Shield

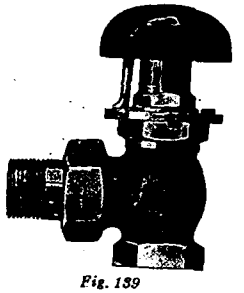


Fig. 139

SOMETHING ENTIRELY NEW IN WATER HEAT REGULATION

We have made a special study of hot water heat regulation and control and are pioneers in the matter of individual radiator control, through a graduated valve, employing the same principle as with steam. If you can modulate, graduate, or regulate individual radiator vapor or vacuum steam heat through a valve (and you can), then why not by the same principle regulate water heat, and, for that matter more consistently than steam, as with water you have something to regulate, while with steam, to allow fire to drop below a given point, you have nothing.

For sleeping rooms, heat regulation with the Marsh Graduated water valves may be controlled with the same ease of operation and certainty of results as is possible with a Modulated valve on a steam system, and at a much less cost than for a vapor or vacuum system installation.

Further, water circulation for each radiator, graduating for same or balancing of system, can be increased from nothing to full pipe capacity and held or locked at any intermediate point, if desired, by simply turning dial so that stop on same will register against indicator or pointer and locking dial in this position, preventing further opening of valve or turning of wheel or lever handle to the left.

These valves cost but little more than our regular water valves and much less than steam modulated valves.

W. F. Hirschman Co., Inc.

Buffalo, N.Y. **Works: Le Roy, N.Y.**

New York, N.Y., 525 Sixth Avenue Boston, Mass., 37 Pearl Street Detroit, Mich., Builders-Trade Exchange

MANUFACTURERS ROOF VENTILATORS

"EFFICO" WIND-DRIVEN ROOF VENTILATORS:

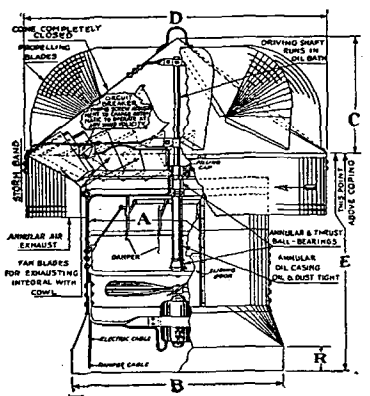
The Effico Ventilator consists of a wind-driven head to which suction blades are permanently connected (on the underside) making an efficient exhaust fan. Rotation of the head creates an exhaust suction in the throat of the ventilator. There are no moving parts.

Bearings.—Effico Bearings are full ball bearings, are solidly enclosed and oil-flooded (also dust and acid *proof*). They are as sturdy as the best automobile bearings, and will run in a dry state for years, but we oil-flood them as an extra precaution.



Effico Rotary Ball Bearing Ventilator Installation, Wind Driven (only) The Effico Wind Electric Also Has the Same Artistic Lines and Pleasing Appearance. Lowest in Height of Rotary Ventilators by Over 60 per cent Average.

All Efficos will draw considerable air at a 1-mile breeze (an apparent calm) without stack or heat assistance. The 30-in. size will rotate (standing start) at .7-oz. pressure, ½-mile breeze, Cowl outlet is over 50 per cent larger than its stack area; this is ample, as no wind enters ventilator to gain the so-called siphonage effect. Suction fan is same size as rotating cowl. Thus each Effico is equipped with fan over 50 per cent greater in diameter than its stack area. Fan pulls air up stack at even the slowest turning movement and wind blowing across the outlet adds to its efficiency.



Detail of Effico Wind Electric Rotary Ball Bearing Ventilator Full Automatic

Note.—Details of Wind Driven (only) Ventilator are Identical with Exception of *Motor Unit.*

CAPACITIES OF EFFICO ROTARY BALL BEARING VENTILATORS

Both Wind Electric and Wind Driven (only)—Cubic Feet of Air Exhausted per Minute

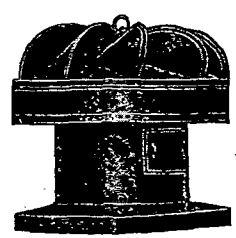
Wind Velocity, Miles per Hour	*Bold Type is Regularly Furnished Wind-Electric Capacity*											
	Temperature Difference in Degrees Fahrenheit in Building and Outside											
	0	10	20	30	0	10	20	30	0	10	20	30
	12-In. Ventilator				18-In. Ventilator				24-In. Ventilator			
5	350	440	515	560	600	850	950	1040	1020	1600	1780	1900
10	430	525	600	625	910	1050	1200	1300	1490	1900	2100	2300
14	480	600	635	700	1050	1200	1300	1400	1800	2230	2460	2590
	30-In. Ventilator				36-In. Ventilator				42-In. Ventilator			
5	1560	2300	2690	2900	2300	3400	3810	4100	3150	4500	5010	5500
10	2300	3210	3490	3600	3250	4200	4720	5050	4390	5700	6300	6800
14	2900	3650	3850	4020	4040	4800	5300	5600	5600	6700	7400	7800
	48-In. Ventilator				54-In. Ventilator				60-In. Ventilator			
5	4000	5900	6700	7400	5100	7300	8450	9500	6500	9300	10600	11900
10	5900	7900	8900	9050	7850	9900	11000	11500	9200	12500	14000	14500
14	7000	9000	10000	10500	9500	11800	12500	12800	11400	14000	15000	16000

Effico Wind Electric Ventilator Dimensions

Ventilator Sizes Corresponding to Those in Table Opposite	Dimensions in Inches—(See Diagram Above)					Thickness of Metal			Hp. of Motor
	A	B	C	D	E	Gauge G. I.		Copper, Oz.	
	Actual Size of Ventilator for Wind Elec. Type	Base	Height of Blades	Diam. of Storm Band	Height to Propeller Blades	Cowl	Base		
12	14	20	8	21¾	32	24	22	16	1/30
18	19	26	10	28½	32	24	22	18	
24	25	38	14	40	40	24	20	18	
30	31	40	14	50	42	24	20	20	⅛
36	37	44	18	60	45	22	18	24	
42	43	50	22	68	51	22	18	24	
48	49	56	24	76	51	22	18	24	¼
54	55	62	24	86	51	22	18	24	
60	61	66	24	98	55	22	18	24	

This apparatus is adjustable to exhaust various quantities of air within the limits of given sizes and is regularly supplied at capacities of 5 miles per hour wind and 10 deg. temperature difference rating. The Wind-Electric will exhaust minimum volume regardless of temperature difference or wind velocity.

Any other capacity can be supplied and the ventilator is adjustable to any constant capacity after installation.



Effico Wind Electric Ventilator, Automatic

Patented May 20, 1922; March 20, 1928; August 21, 1928.

The Effico Wind Electric Ventilator, Full Automatic

Recommended for those installations which require a definite minimum exhaust at all times or which may require an unusually heavy exhaust at intermittent periods. This is the regular Effico equipped with an auxiliary electrically operated fan placed in the ventilator throat just below the regular fan. The throat is slightly enlarged to allow for the motor.

Handsomely painted in red or any desired color and made of galvanized sheets. Also in copper, monel metal, lead clad, aluminum, Cop-r-loy, extra-refined Cop-r-loy.

Principle of Operation of Wind Electric Ventilator—When the wind is blowing sufficiently to remove the desired amount of air from the building being ventilated, the electric motor is still. Instantly, when the wind *turbine moves below a* previously determined number of revolutions, the electric motor starts automatically and carries the load. The entire apparatus is noiseless, the motor is of fully enclosed type, will run for six months without oiling, will not heat under constant running.

Special Advantages—Besides the regular automatic operation, the motor may also be so connected as to give a maximum exhaust capacity (running full speed) by manual control, thus allowing a great volume of air to be exhausted at will.

Effico Internal Louver Unit Ventilators

The Effico internal louver unit comprises the Effico rotary ball bearing ventilator head constructed with a specially short base, or neck. In this base is built a circular multiple blade louver damper. The damper is carefully balanced and heavily constructed. The blades lap and are fitted in a circular frame. It is adaptable for manual control, but is intended for a thermostatic control system. The roof base is very low, is part of this unit and is supplied with either the square or round base.

The roof base and the ventilator head are connected by means of angle iron companion rings, which give solidity and facilitate the taking down of the ventilator when *required. Each ventilator* neck has also a tight fitting door to give free access to the louvers and to the operating motor. The operating motor is suspended underneath the damper to a cross brace. The object of the specially low base and the low roof base is to make the entire unit as low to the roof as possible.

Effico Louver Dampers

Made of stretcher leveled sheet steel. The pneumatic damper motor is supplied and installed with these units unless not desired. (Note specifications below).

Effico Louver Unit

Low height. The Effico louver unit sets very low (note dimensions at right).

Height above Coping

Louver Unit "C" dimension should be above coping.

Effico Rotary Ball Bearing Ventilator Head

The Effico rotary ball bearing ventilator head is already lower in height by 50 per cent than other rotary types of ventilator. By using the construction as outlined above, the entire unit is brought as *low* to the roof as is permissible to still allow the air free exhausting, and to maintain the outlets above the snowline. By adopting the circular multiple louvers, of which we are the inventors; we can standardize on sizes and build the round louver for considerably less than the square or rectangular styles, many of which we have built in the past years.

By installing same in the neck of the ventilator at our shop, we not only give a perfect fit, but also eliminate all indefiniteness as to the correct location and size of the damper and cut the installing cost to one-quarter. It is also easier to install the operating motor and makes it more accessible. The size of the damper is the full size of the stack, and yet is about 40 per cent smaller in area than those heretofore used in the square or rectangular louver, again reducing the cost considerably. By supplying the contractor with the complete unit the builder is assured of a well designed, uniform and complete apparatus.

Heretofore, the contractor purchased the ventilator from one manufacturer, probably built the roof base himself, and purchased the dampers elsewhere, or even the dampers were supplied and installed by another contractor. This added materially to the cost.

Heads only. Effico Heads without dampers are also supplied.

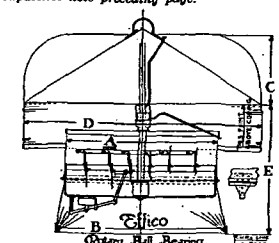
Suggested Specificatons

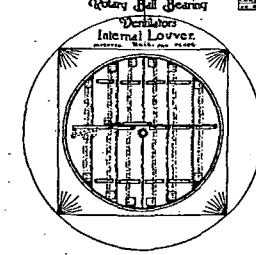
The roof ventilators shall be of the sizes as shown in plans, [square base] [round base] style to be made of [galvanized steel] [Cop-r-loy] [copper]. [The pneumatic damper motor to be supplied with these units]. [Shall be supplied by the heating and ventilating Contractor]. They shall be the Effico Internal Louver Unit Ventilators as manufactured by the W. F. Hirschman Co., Inc., Buffalo, N.Y.

Effico Louver Unit Sizes and Dimensions

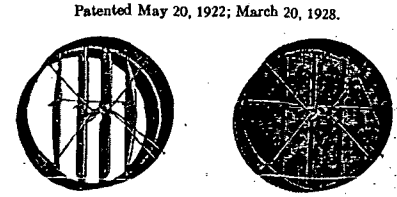
Dimensions, Inches					Galvanized Steel Gauge		Net Wght., Lb.	Copper, Oz.	Code for Telegraphy
A	B	C	D	E	Cowl	Base			
18	20	10	28½	23	24	24	90	16	vale
24	30	14	40	30	22	22	140	18	valet
30	36	14	50	32	22	20	190	20	vive
36	42	18	60	32	22	18	225	24	varve
42	48	22	68	43	22	18	350	24	vetch
48	54	24	76	43	22	18	400	24	vax
54	60	24	86	43	22	18	600	24	vaid
60	66	24	98	43	20	18	710	24	valor
66	72	30	103½	49	20	18	800	24	vamp
72	80	30	114	54	20	18	880	24	vane
84	92	36	130	54	18	16	1050	24	vang
96	116	45	153	54	18	16	1200	24	van

For round bases, "E" dimension remains the same.
For capacities note preceding page.





Patented May 20, 1922; March 20, 1928.



Open *Closed*

The Multiple Circular Louver Damper in Neck of Ventilator

The Swartwout Company

Swartwout Rotary Ball Bearing Ventilators

18551 Euclid Avenue

Cleveland, Ohio

Branch Offices

New York, N.Y., 103 Park Ave.
Pittsburgh, Pa., 1009 Diamond Bank Bldg.

Branch Offices

Chicago, Ill., 549 W. Randolph St.
St. Louis, Mo., 1124 Chemical Bldg.

PRODUCTS

Swartwout Rotary Ball Bearing Ventilators.

Construction

Swartwout Rotary Ball Bearing Ventilators are built of Armco Ingot Iron or special metals as required. All joints are double seamed—no bolts being used. All interior members are given a special rust-resisting coating after punching and forming.

Bronze bearings revolving on bronze balls provide free rotation without the necessity of lubrication. Outside louver dampers are controlled easily from within the building by a special louver attachment which permits definite setting of area opening without necessity of fastening the chain. Bases to fit standard sizes are made of the same metal, two gauges heavier than the ventilator.

Erection and Operation

Swartwout Rotary Ball Bearing Ventilators save the factory completely assembled, making erection on the building a quickly accomplished job.



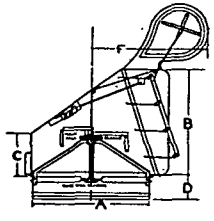
Swinging freely with the wind, Swartwout Ventilators provide a continual suction of air from within the building. Capacity is regulated by setting the louver dampers at the most desirable angle. Full area opening will, of course, provide maximum ventilation.

Survey Service

Maintaining a staff of ventilation *experts* for the purpose, The Swartwout Company co-operates with heating and ventilating engineers by studying their problems and making helpful recommendations in the form of a Swartwout Survey. There is no charge for this service. However, if you choose to follow the recommendations of a Swartwout Survey, you are assured of guaranteed ventilation.

Write for a copy of "The Gospel of Fresh Air," a new book devoted to the subject of ventilation.

Dimensions, Weights and Gauges of Swartwout Ventilators



For dimensions, "A," "B," "C," "D," "F," in inches see table below.

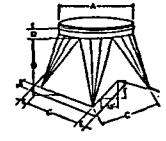
In ordering only dimension "A" is required.

Installation

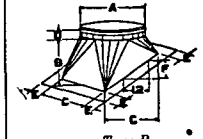
To insure proper installation and immediate satisfaction, complete directions for mounting are supplied on each ventilator.

A	B	C	D	F	Gauge Iron	Wt. Copper, Oz.	Net Wt., Lb.	Crated Wt., Lb.
10	9⅛	4	5	11½	24	18	15	20
12	11	4¾	5	14¼	24	18	20	25
14	12⅞	5¾	5½	15½	24	18	30	30
16	14¾	6	5½	17	24	18	35	40
18	16½	6⅝	6½	19	24	18	45	55
20	18½	7⅜	6½	21	24	18	50	65
24	22	9	6½	24½	24	20	60	80
30	27½	11⅝	9⅛	30	22	24	120	175
36	33	13½	11	34½	22	24	160	240
42	38½	15¾	11¼	41¼	20	28	225	390
48	44	18⅛	11¼	46½	20	28	320	465
54	49½	20¼	13¾	47	20	28	485	690
60	55	22½	15½	61	20	28	560	750
66	60½	24¼	16¾	62½	20	28	650	825
72	66	27	16¾	67½	20	28	780	1000

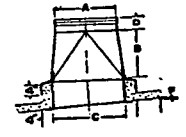
Dimensions, Weights and Gauges of Swartwout Bases



Type A



Type B



Type C

A	B	C	D	E	F	Gauge Iron	Wt. Copper, Oz.	Aver. Net Wt., Lb.	Aver. Crated Wt., Lb.
10	18	14	5	5	Required Dimension Slope per Foot	22	24	13	15
12	18	16	5	5		22	24	18	20
14	18	18	5	5		22	24	26	28
16	18	20	5	5		22	24	35	37
18	18	22	5	5		22	24	38	40
20	22	24	5	5		22	24	45	50
24	22	28	5	5		22	24	55	65
30	22	34	5	5		20	28	80	95
36	22	40	5	5		20	28	95	110
42	22	46	5	5		18	32	105	125
48	22	52	5	5		18	32	115	135
54	22	58	5	5		18	32	125	150
60	22	64	5	5		18	32	140	165
66	22	70	5	5		18	32	155	185
72	22	76	5	5		18	32	170	200

Index to Modern Equipment

American Society of Heating and Ventilating Engineers Guide 1929

AIR COCKS (*See Cocks, Air*)

AIR CONDITIONING
American Blower Corp.
Atmospheric Conditioning Corp.
Bayley Blower Co.
Bentz Engineering Corp.
Bishop & Babcock Sales Co., The
Buckeye Blower Co., The
Buffalo Forge Co.
Carrier Air Conditioning Corp. of America
Carrier Engineering Corp.
Clarage Fan Co.
Cooling and Air Conditioning Corp.
De Bothezat Impeller Co.
Garden City Fan Co.
General Air Filters Corp.
Grinnell Co., Inc.
Ilg Electric Ventilating Co.
Johnson Fan & Blower Co.
Langenberg Mfg. Co.
Midwest Air Filters, Inc.
National Air Filter Co.
New York Blower Co.
Niagara Blower Co.
Peerless Unit Ventilation Co., Inc.
Reed Air Filter Co., Inc.
Shipp, C. C., & Co.
Skinner Bros. Mfg. Co., Inc.
Sturtevant, B. F., Co.
Trane Co., The
United States Ozone Co.
Wing, L. J., Mfg. Co.
York Heating & Ventilating Corp.

AIR COOLERS
Aerofin Corp.
American Blower Corp.
Bayley Blower Co.
Buffalo Forge Co.
Clarage Fan Co.
General Air Filters Corp.
Ilg Electric Ventilating Co.
McCord Radiator & Mfg. Co.
Niagara Blower Co.
Rome Brass Radiator Corp.
Rome-Turney Radiator Co., The
Schutte & Koerting Co.
Sturtevant, B. F., Co.
Trane Co., The
York Heating & Ventilating Corp.

AIR DIFFUSERS (*See Diffusers, Air*)

AIR DRYING (*See Drying Apparatus*)

AIR ELIMINATORS (*See Eliminators, Air*)

AIR FILTERS (*See Filters, Air*)

AIR HEATERS (*See Heaters, Air*)

AIR METERS (*See Meters, Air*)

AIR PUMPS (*See Pumps, Air*)

AIR TESTING INSTRUMENTS
American Blower Corp.
Hill, E. Vernon, Co.

AIR VALVES (*See Valves, Air*)

AIR WASHERS
American Blower Corp.
Atmospheric Conditioning Corp.
Bayley Blower Co.
Bentz Engineering Corp.
Bishop & Babcock Sales Co., The
Buffalo Forge Co.
Clarage Fan Co.
Cooling and Air Conditioning Corp.
De Bothezat Impeller Co.
General Air Filters Corp.
Ilg Electric Ventilating Co.
Midwest Air Filters, Inc.
New York Blower Co.
Niagara Blower Co.
Reed Air Filter Co., Inc.
Sturtevant, B. F., Co.
York Heating & Ventilating Corp.

AMMONIA COILS (*See Coils, Ammonia*)

ASBESTOS AND INSULATING PRODUCTS
Armstrong Cork & Insulation Co.
Banner Rock Products Co.
Samuel Cabot, Inc.
Celotex Co.
Flax-li-num Insulating Co.
Insulating Products Corp.
Insulite Co., The
Johns-Manville Corp.
MacAndrews & Forbes Co.
Masonite Corp.
National Radiator Corp.
Pantasote Co., Inc.
Ric-wiL Co., The
Sprayo-Flake Co.
Stewart Inso Board Co.
United States Gypsum Co.
Universal Gypsum & Lime Co.
Wood Conversion Co.

ASBESTOS—Sheet
Johns-Manville Corp.

AUTOMATIC FURNACES (*See Furnaces, Automatic*)

AUTOMATIC STARTERS
Absolute Con-tac-tor Corp.
General Electric Co.

BAKING EQUIPMENT
Bentz Engineering Corp.
Clarage Fan Co.
Cooling and Air Conditioning Corp.
Swartwout Co., The

BLAST GATES (*See Gates, Blast*)

BLOWERS—Centrifugal
American Blower Corp.
Bayley Blower Co.
Buckeye Blower Co., The
Buffalo Forge Co.
Clarage Fan Co.
Garden City Fan Co.
General Electric Co.
Ilg Electric Ventilating Co.
Johnson Fan & Blower Co.
Nesbitt, John J., Inc.
New York Blower Co.
Niagara Blower Co.
Skinner Brothers Mfg. Co., Inc.
Sturtevant, B. F., Co.
York Heating & Ventilating Corp.

Fan
American Blower Corp.
Bayley Blower Co.
Bishop & Babcock Sales Co., The
Buckeye Blower Co., The
Buffalo Forge Co.
Clarage Fan Co.
Combustion Specialties Corp.
De Bothezat Impeller Co.
Garden City Fan Co.
General Electric Co.
Hirschman, W. F., Co., Inc.
Ilg Electric Ventilating Co.
Johnson Fan & Blower Co.
Langenberg Mfg. Co.
Nash Engineering Co.
Nesbitt, John J., Inc.
New York Blower Co.
Niagara Blower Co.
Skinner Bros. Mfg. Co., Inc.
Sturtevant, B. F., Co.
Wing, L. J., Mfg. Co.
York Heating & Ventilating Corp.

Forced Draft
American Blower Corp.
Bayley Blower Co.
Buffalo Forge Co.
Clarage Fan Co.
Combustion Specialties Corp.
De Bothezat Impeller Co.
Garden City Fan Co.
Ilg Electric Ventilating Co.
Sturtevant, B. F., Co.
Wing, L. J., Mfg. Co.

Pressure
American Blower Corp.
Bayley Blower Co.
Buffalo Forge Co.
Clarage Fan Co.
Combustion Specialties Corp.
De Bothezat Impeller Co.
Garden City Fan Co.
Ilg Electric Ventilating Co.
Johnson Fan & Blower Co.
Nash Engineering Co.
New York Blower Co.
Sturtevant, B. F., Co.
Wing, L. J., Mfg. Co.

Catalogue Data of Manufacturers listed can be located by referring to pages 841 to 844

Turbine
American Blower Corp.
Bayley Blower Co.
Buffalo Forge Co.
General Electric Co.
Sturtevant, B. F., Co.
Wing, L. J., Mfg. Co.

Ventilating
American Blower Corp.
Bayley Blower Co.
Bishop & Babcock Sales Co., The
Buckeye Blower Co., The
Buffalo Forge Co.
Clarage Fan Co.
De Bothezat Impeller Co.
Garden City Fan Co.
General Electric Co.
Hirschman, W. F., Co., Inc.
Ilg Electric Ventilating Co.
Johnson Fan & Blower Co.
Langenberg Mfg. Co.
National Air Filter Co.
Herman Nelson Corp.
New York Blower Co.
Niagara Blower Co.
Peerless Unit Ventilation Co., Inc.
Reed Air Filter Co.
Rome Brass Radiator Corp.
Shipp, C. C., & Co.
Skinner Bros. Mfg. Co., Inc.
Sturtevant, B. F., Co.
Trane Co., The
Wing, L. J., Mfg. Co.
York Heating & Ventilating Corp.

BOILER—Compounds (*See Compounds, Boiler*)

Cleanser
Vinco Co., Inc., The

Controllers (*See Controllers*)

Coverings (*See Asbestos and Insulating Products*)

Feeders
Kieley & Mueller, Inc.
McAlear Mfg. Co.
McDonnell & Miller
Mueller Steam Specialty Co., Inc.
Swartwout Co., The

Feed Pumps (*See Pumps*)

Headers (*See Headers*)

Insulation
Armstrong Cork & Insulation Co.
Insulating Products Corp.
Johns-Manville Corp.
Pantasote Co., Inc.
Stewart Inso Board Co.

Protecting Devices
American Radiator Co.
Hoffman Specialty Co.
Kainer & Co.
Kieley & Mueller, Inc.
Marsh, Jas. P., & Co.
McDonnell & Miller
National Regulator Co.
Neptune Meter Co.
Trane Co., The
U. S. Radiator Corp.

Scale Remover (*See Scale Remover, Boiler*)

BOILERS—Furnace Heat
American Gas Products Corp.

Heating (*Automatic Heat*)
American Gas Products Corp.
Bigelow Co., The
Leader Iron Works
Molby Boiler Co., Inc.
Spencer Heater Co.
Weil-McLain Co.

Heating (*Coal Fired*)
American Radiator Co.
Ames Iron Works
Bigelow Co., The
Burnham Boiler Corp.
Coatesville Boiler Works
Edge Moor Iron Co.
Fitzgibbons Boiler Co., Inc.
Frost Mfg. Co., The
Harrisburg Star Boiler Corp.
Heggie-Simplex Boiler Co.
Herbert Boiler Co.
Kewanee Boiler Corp.
Molby Boiler Co., Inc.
Monitor Boiler Co.
National Radiator Corp.
Newport Boiler Co.
Oil City Boiler Works
Pacific Steel Boiler Corp.
Page, Wm. H., Boiler Co.
Pierce, Butler & Pierce Mfg. Corp.
Prox, Frank, Co.
Richardson & Boynton Co.
Richmond Radiator Co.
Smith, H. B., Co., The
Smith Twin Tubular Boiler Co.
Spencer Heater Co.
Stanwood Corp., The
Thatcher Co., The
Titusville Iron Works Co., The
U. S. Radiator Corp.
Weil-McLain Co.

Heating (*Electric*)
Bigelow Co., The

Heating (*Gas Fired*)
American Gas Products Corp.
American Radiator Co.
Ames Iron Works
Bigelow Co., The
Burnham Boiler Corp.
Edge Moor Iron Co.
Fitzgibbons Boiler Co., Inc.
Frost Mfg. Co., The
General Air Filters Corp.
Heggie-Simplex Boiler Co.
Herbert Boiler Co.
Kewanee Boiler Corp.
Leader Iron Works
Monitor Boiler Co.
National Radiator Corp.
Neptune Meter Co.
Newport Boiler Co.
Oil City Boiler Works
Pacific Steel Boiler Corp.
Page, Wm. H., Boiler Co.
Pierce, Butler & Pierce Mfg. Corp.
Richardson & Boynton Co.
Richmond Radiator Co.
Smith Twin Tubular Boiler Co.
Spencer Heater Co.
Stanwood Corp., The
Titusville Iron Works Co., The
U. S. Radiator Corp.
Weil-McLain Co.

Heating (*Magazine Feed*)
Newport Boiler Co.
Molby Boiler Co., Inc.
Pierce, Butler & Pierce Mfg. Corp.
Spencer Heater Co.
Weil-McLain Co.

Heating (*Oil Fired*)
American Radiator Co.
Ames Iron Works
Bigelow Co., The
Burnham Boiler Corp.
Coatesville Boiler Works
Edge Moor Iron Co.
Fitzgibbons Boiler Co., Inc.
Frost Mfg. Co., The
General Air Filters Corp.
Harrisburg Star Boiler Corp.
Heggie-Simplex Boiler Co.
Herbert Boiler Co.
Kewanee Boiler Corp.
Leader Iron Works
Monitor Boiler Co.
National Radiator Corp.
Newport Boiler Co.
Oil City Boiler Works
Pacific Steel Boiler Corp.
Page, Wm. H., Boiler Co.
Pierce, Butler & Pierce Mfg. Corp.
Richmond Radiator Co.
Smith, H. B., Co., The
Smith Twin Tubular Boiler Co.
Spencer Heater Co.
Stanwood Corp., The
Sturtevant, B. F., Co.
Thatcher Co., The
Titusville Iron Works Co., The
U. S. Radiator Corp.
Weil-McLain Co.

Portable
Ames Iron Works

Tubular
Ames Iron Works
Bigelow Co., The
Burnham Boiler Corp.
Coatesville Boiler Works
Fitzgibbons Boiler Co., Inc.
Frost Mfg. Co., The
Harrisburg Star Boiler Corp.
Heggie-Simplex Boiler Co.
Herbert Boiler Co.
Kewanee Boiler Corp.
Leader Iron Works
Oil City Boiler Works
Pierce, Butler & Pierce Mfg. Corp.
Smith Twin Tubular Boiler Co.
Spencer Heater Co.
Stanwood Corp., The
Titusville Iron Works Co., The

Upright
Ames Iron Works

Water Supply, Hot (*See Heaters, Tank*)

BRACKETS (*See Hangers, Pipe and Radiator, and Radiator Brackets*)

BREAKERS
General Electric Co.

BREECHINGS
Bigelow Co., The
Coatesville Boiler Works
Pierce, Butler & Pierce Mfg. Corp.

Catalogue Data of Manufacturers listed can be located by referring to pages 841 to 844

BURNERS—Oil (*For Heating Boilers and Furnaces*)
Automatic Burner Corp.
Ballard Oil Equipment Co.
Hardinge Brothers, Inc.
May Oil Burner Corp.
Petroleum Heat & Power Co.
Winslow Boiler & Engineering Co.

CABINETS—Heat
Buckeye Blower Co., The
Circulair Heat, Inc.
Copper Radiator Sales Corp.
McQuay Radiator Corp.
Herman Nelson Corp.
Rome Brass Radiator Corp.
Trane Co., The

CALORIMETERS—Steam
Consolidated Ashcroft Hancock Co., Inc. (American Schaeffer & Budenberg Div.)
Ellison Draft Gage Co.

CEMENT—Asbestos and Insulating (*See Asbestos*)
Banner Rock Products Co.
Insulating Products Corp.
Johns-Manville Corp.

Fire Brick
Johns-Manville Corp.

Insulating
Armstrong Cork & Insulation Co.
Banner Rock Products Co.
Insulating Products Corp.
Johns-Manville Corp.
Pantasote Co., Inc.
Stewart Inso Board Co.

High Temperature
Banner Rock Products Co.
Insulating Products Corp.
Johns-Manville Corp.

Pipe Joint
Crane Co.
Grinnell Co., Inc.
Johns-Manville Corp.

Water Proof
Banner Rock Products Co.
Johns-Manville Corp.

CENTRIFUGAL DRYERS (*See Drying Apparatus*)

CHIMNEYS—Steel
Bigelow Co., The

CLEANSER, BOILER AND HEATING SYSTEM
Vinco Co., Inc., The

COAL SAVER
American Blower Corp.
Combustion Specialties Corp.
Wing, L. J., Mfg. Co.

COCKS—Air
American Radiator Co.
Bishop & Babcock Sales Co., The
Crane Co.
Mueller Co.

Boiler Drain
Crane Co.
Mueller Co.

Boiler Supply
Crane Co.
Mueller Co.

Gage
Bishop & Babcock Sales Co., The
Consolidated Ashcroft Hancock Co., Inc. (American Schaeffer & Budenberg Div.)
Crane Co.
Jenkins Bros.
Marsh, Jas. P., & Co.
O-E Specialty Mfg. Co.
Wright-Austin Co.

COILS—Ammonia
Badger, E. B., & Sons Co.
Crane Co.
Grinnell Co., Inc.
McCord Radiator & Mfg. Co.
Whitlock Coil Pipe Co.

Blast
Aerofin Corp.
American Blower Corp.
American Radiator Co.
Bayley Blower Co.
Buckeye Blower Co., The
Buffalo Forge Co.
McCord Radiator & Mfg. Co.
New York Blower Co.
Niagara Blower Co.
Rome Brass Radiator Corp.
Rome-Turney Radiator Co., The
Schutte & Koerting Co.
Stickle Steam Specialties Co.
Sturtevant, B. F., Co.
Trane Co., The
York Heating & Ventilating Corp.

Pipe
American Blower Corp.
Badger, E. B., & Sons
Bayley Blower Co.
Buckeye Blower Co., The
Buffalo Forge Co.
Crane Co.
Garden City Fan Co.
Grinnell Co., Inc.
Niagara Blower Co.
Sturtevant, B. F., Co.
Whitlock Coil Pipe Co.
York Heating & Ventilating Corp.

Tank
Badger, E. B., & Sons
Crane Co.
Davis Engineering Corp.
Kewanee Boiler Corp.
Leader Iron Works
Niagara Blower Co.
Stanwood Corp., The
Whitlock Coil Pipe Co.

COLLECTORS, DUST (*See Dust Collectors*)

COLUMNS—Water
American Gas Products Corp.
American Radiator Co.
Burnham Boiler Corp.
Consolidated Ashcroft Hancock Co., Inc. (American Schaeffer & Budenberg Div.)
Crane Co.
Kieley & Mueller, Inc.
Oil City Boiler Works
Page, Wm. H., Boiler Co.
Titusville Iron Works Co., The
U. S. Radiator Corp.

Water Safety Alarm
Kieley & Mueller, Inc.
Wright-Austin Co.

COMPOUNDS—Boiler
Richardson & Boynton Co.
Vinco Co., Inc., The

COMPRESSORS
American Steam Pump Co.
Bishop & Babcock Sales Co., The
General Electric Co.
Leader Iron Works
Nash Engineering Co.
O-E Specialty Mfg. Co.
Powers Regulator Co.
Sturtevant, B. F., Co.
Trane Co., The

CONCRETE INSERTS (*See Inserts, Concrete*)

CONCEALED RADIATORS (*See Radiators, Concealed*)

CONDENSERS
Alberger Heater Co.
American Steam Pump Co.
Bell & Gossett Co.
Buffalo Steam Pump Co.
Davis Engineering Corp.
Frank, O. E., Heater & Engineering Co., Inc.
General Air Filters Corp.
McCord Radiator & Mfg. Co.
Rome Brass Radiator Corp.
Whitlock Coil Pipe Co.

CONDUIT—Underground
American District Steam Co.
General Electric Co.
Johns-Manville Corp.
Ric-wiL Co., The

CONTROL EQUIPMENT
Absolute Con-tac-tor Corp.
American Gas Products Corp.
American Radiator Co.
Consolidated Ashcroft Hancock Co., Inc. (American Schaeffer & Budenberg Div.)
Direct Control Valve Co.
General Electric Co.
Johnson Service Co.
Klipfel Mfg. Co.
McDonnell & Miller
Mueller Co.
National Regulator Co.
Powers Regulator Co.
Sterling Engineering Co.
Webster Tallmadge & Co., Inc.
Taylor Instrument Cos.
Trane Co., The
U. S. Radiator Corp.

CONTROL SWITCHES (*See Switches, Control*)

CONTROLLERS—Automatic Air
Absolute Con-tac-tor Corp.
American Radiator Co.

Catalogue Data of Manufacturers listed can be located by referring to pages 841 to 844

Boiler
- Absolute Con-tac-tor Corp.
- American Gas Products Corp.
- American Radiator Co.
- Consolidated Ashcroft Hancock Co., Inc. (American Schaeffer & Budenberg Div.)
- Davis, G. M., Regulator Co.
- Direct Control Valve Co.
- Fitzgibbons Boiler Co., Inc.
- Kieley & Mueller, Inc.
- Klipfel Mfg. Co.
- Mason Regulator Co.
- McAlear Mfg. Co., The
- McDonnell & Miller
- Marine-Galligan Co., Inc.
- Mueller Steam Specialty Co., Inc.
- National Regulator Co.
- Powers Regulator Co.
- Sarco Co., Inc.
- Swartwout Co., The
- Taylor Instrument Cos.
- Trane Co., The
- U. S. Radiator Corp.

Electric Heat
- Absolute Con-tac-tor Corp.
- American Radiator Co.
- Consolidated Ashcroft Hancock Co., Inc. (American Schaeffer & Budenberg Div.)
- Copper Radiator Sales Corp.
- Ilg Electric Ventilating Co.
- Johnson Service Co.
- Klipfel Mfg. Co.
- National Regulator Co.
- Powers Regulator Co.
- Rome Brass Radiator Corp.
- Taylor Instrument Cos.

Fan Engine
- American Blower Corp.
- Bayley Blower Co.
- Clarage Fan Co.
- Frost Mfg. Co., The
- Kieley & Mueller, Inc.
- Klipfel Mfg. Co.
- Mason Regulator Co.
- McAlear Mfg. Co.
- Mueller Co.
- Mueller Steam Specialty Co., Inc.
- National Regulator Co.
- Sturtevant, B. F., Co.
- Swartwout Co., The

Feed Water
- American Radiator Co.
- Burnham Boiler Corp.
- Consolidated Ashcroft Hancock Co., Inc, (American Schaeffer & Budenberg Div.)
- Davis, G. M., Regulator Co.
- Economy Pumping Machinery Co.
- Kieley & Mueller, Inc.
- Klipfel Mfg. Co.
- Mason Regulator Co.
- McAlear Mfg. Co.
- McDonnell & Miller
- Mueller Steam Specialty Co., Inc.
- O-E Specialty Mfg. Co.
- Sarco Co., Inc.
- Taylor Instrument Cos.
- U. S. Radiator Corp.

Gas Burner
- Absolute Con-tac-tor Corp.
- American Radiator Co.
- Consolidated Ashcroft Hancock Co., Inc. (American Schaeffer & Budenberg Div.)
- McAlear Mfg. Co.

Motor
- Absolute Con-tac-tor Corp.
- American Radiator Co.
- Consolidated Ashcroft Hancock Co., Inc. (American Schaeffer & Budenberg Div.)
- Economy Pumping Machinery Co.
- General Electric Co.
- Mason Regulator Co.
- McAlear Mfg. Co.
- Trane Co., The
- U. S. Radiator Corp.

Pump
- Absolute Con-tac-tor Corp.
- American Radiator Co.
- American Steam Pump Co.
- Buffalo Steam Pump Co.
- Chicago Pump Co.
- Consolidated Ashcroft Hancock Co., Inc. (American Schaeffer & Budenberg Div.)
- Davis, G. M., Regulator Co.
- Dunham, C. A., Co.
- Economy Pumping Machinery Co.
- Finn Pump, M. J., Mfg. Co.
- General Electric Co.
- Kieley & Mueller, Inc.
- Klipfel Mfg. Co.
- Mason Regulator Co.
- McAlear Mfg. Co.
- Mueller Steam Specialty Co., Inc.
- Skidmore Corp.
- Stickle Steam Specialties Co.
- Swartwout Co., The
- Trane Co., The
- U. S. Radiator Corp.

Shower Bath
- Consolidated Ashcroft Hancock Co., Inc. (American Schaeffer & Budenberg Div.)
- Crane Co.
- Mueller Co.
- Powers Regulator Co.

Tank
- Absolute Con-tac-tor Corp.
- American Radiator Co.
- Consolidated Ashcroft Hancock Co., Inc. (American Schaeffer & Budenberg Div.)
- Davis, G. M., Regulator Co.
- Kieley & Mueller, Inc.
- Klipfel Mfg. Co.
- Mason Regulator Co.
- McAlear Mfg. Co.
- Mueller Steam Specialty Co., Inc.
- Powers Regulator Co.
- Sarco Co., Inc.
- Stickle Steam Specialties Co.
- Taylor Instrument Cos.

Unit Heaters
- Absolute Con-tac-tor Corp.
- American Radiator Co.
- Bayley Blower Co.
- National Regulator Co.

Temperature (*See Regulators, Temperature*)

CONVEYING SYSTEMS (*See Systems, Dust Collecting and Exhaust*)

COOLING EQUIPMENT—Building
- Aerofin Corp.
- American Blower Corp.
- Atmospheric Conditioning Corp.
- Bayley Blower Co.
- Bishop & Babcock Sales Co., The
- Buffalo Forge Co.
- Carrier Air Conditioning Corp. of America
- Carrier Engineering Corp.
- Clarage Fan Co.
- Cooling and Air Conditioning Corp.
- Finn Pump, M. J., Mfg. Co.
- Frank, O. E., Heater & Engineering Co., Inc.
- Garden City Fan Co.
- General Air Filters Corp.
- Hirschman, W. F., Co., Inc.
- Ilg Electric Ventilating Co.
- Niagara Blower Co.
- Rome Brass Radiator Corp.
- Schutte & Koerting Co.
- Sturtevant, B. F., Co.
- Swartwout Co., The
- Trane Co., The
- York Heating & Ventilating Corp.

COOLING TOWERS
- American Blower Corp.
- Bayley Blower Co.
- Buffalo Forge Co.
- Hirschman, W. F., Co., Inc.
- Niagara Blower Co.
- Sturtevant, B. F., Co.

COUPLINGS
- Mogul Machine Co.

COVERING—Boiler (*See Asbestos and Insulating Products*)

Magnesia
- Insulating Products Corp.
- Johns-Manville Corp.

Pipe and Tank
- Armstrong Cork & Insulation Co.
- Banner Rock Products Co.
- Insulating Products Corp.
- Johns-Manville Corp.
- Ric-wiL Co., The

DAMPERS
- American Foundry & Furnace Co.

DAMPER—Quadrants
- York Heating & Ventilating Corp.

DAMPER REGULATORS (*See Regulators, Damper*)

DEHUMIDIFYING APPARATUS
- American Blower Corp.
- Atmospheric Conditioning Corp.
- Bayley Blower Co.
- Bentz Engineering Corp.
- Buckeye Blower Co., The
- Buffalo Forge Co.
- Carrier Engineering Corp.
- Clarage Fan Co.
- Cooling and Air Conditioning Corp.
- Finn Pump, M. J., Mfg. Co.
- General Air Filters Corp.
- Ilg Electric Ventilating Co.
- New York Blower Co.
- Niagara Blower Co.
- Skinner Bros. Mfg. Co., Inc.
- Stickle Steam Specialties Co.
- Sturtevant, B. F., Co.
- York Heating & Ventilating Corp.

Catalogue Data of Manufacturers listed can be located by referring to pages 841 to 844

DIFFUSERS—Air
- American Foundry & Furnace Co.
- Bayley Blower Co.
- Bentz Engineering Corp.
- Buckeye Blower Co., The
- Carrier Engineering Corp.
- Cooling and Air Conditioning Corp.
- Knowles Mushroom Ventilator Co.
- Niagara Blower Co.
- Shipp, C. C., & Co.
- Sturtevant, B. F., Co.

DRAFT GAGES (*See Gages, Draft*)

DRYING APPARATUS
- American Blower Corp.
- American Foundry & Furnace Co.
- Atmospheric Conditioning Corp.
- Bayley Blower Co.
- Bentz Engineering Corp.
- Bishop & Babcock Sales Co., The
- Buckeye Blower Co., The
- Buffalo Forge Co.
- Carrier Engineering Corp.
- Clarage Fan Co.
- Cooling and Air Conditioning Corp.
- Economy Pumping Machinery Co.
- Finn Pump, M. J., Mfg. Co.
- Garden City Fan Co.
- General Air Filters Corp.
- Hirschman, W. F., Co., Inc.
- Ilg Electric Ventilating Co.
- Langenberg Mfg. Co.
- New York Blower Co.
- Niagara Blower Co.
- Rome Brass Radiator Corp.
- Skinner Bros. Mfg. Co., Inc.
- Stickle Steam Specialties Co.
- Sturtevant, B. F., Co.
- Swartwout Co., The
- Trane Co., The
- United States Ozone Co.
- Wing, L. J., Mfg. Co.
- York Heating & Ventilating Corp.

DUST COLLECTING SYSTEMS (*See Systems, Dust Collecting*)

DUST COLLECTORS
- American Blower Corp.
- Bayley Blower Co.
- Buffalo Forge Co.
- Carrier Engineering Corp.
- Garden City Fan Co.
- General Air Filters Corp.
- Midwest Air Filters, Inc.
- National Air Filter Co.
- New York Blower Co.
- Niagara Blower Co.
- Reed Air Filter Co.
- Skinner Bros. Mfg. Co., Inc.
- Sturtevant, B. F., Co.
- Whiting Corp.

DUST COUNTERS
- Hill, E. Vernon, Co.

DUST FILTERS
- Bayley Blower Co.
- Drying Systems, Inc.
- General Air Filters Corp.
- Midwest Air Filters, Inc.
- National Air Filter Co.
- Reed Air Filters Co., Inc.
- Whiting Corp.

DUST SEPARATORS (*See Separators, Dust*)

ELBOWS—Radiator
- American District Steam Co.
- American Radiator Co.
- Burnham Boiler Corp.
- Crane Co.
- U. S. Radiator Corp.

ELECTRIC HEATING APPARATUS
- General Electric Co.
- Hoffman Specialty Co., Inc.
- Rome Brass Radiator Corp.

ELECTRIC MOTORS (*See Motors, Electric*)

ELIMINATORS—Air
- American District Steam Co.
- Bishop & Babcock Sales Co., The
- Dunham, C. A., Co.
- General Air Filters Corp.
- Grinnell Co., Inc.
- Hoffman Specialty Co., Inc.
- Kieley & Mueller, Inc.
- Marsh, Jas. P., & Co.
- McAlear Mfg. Co.
- Milwaukee Valve Co.
- Monash-Younker Co., Inc.
- Mueller Steam Specialty Co., Inc.
- New York Blower Co.
- O-E Specialty Mfg. Co.
- Sarco Co., Inc.
- Skinner Bros. Mfg. Co., Inc.
- Sterling Engineering Co.
- Sturtevant, B. F., Co.
- Trane Co., The

ENGINES—Fan
- American Blower Corp.
- Bayley Blower Co.
- Buffalo Forge Co.
- Clarage Fan Co.
- Frost Mfg. Co., The
- New York Blower Co.
- Sturtevant, B. F., Co.

Steam (*Automatic, High Speed, Throttling, Uno-Flow, and Vertical*)
- American Blower Corp.
- Ames Iron Works
- Clarage Fan Co.
- Frost Mfg. Co., The
- Herbert Boiler Co.
- Pierce, Butler & Pierce Mfg. Corp.
- Sturtevant, B. F., Co.
- Titusville Iron Works Co., The

EXHAUST FANS (*See Fans, Exhaust*)

EXHAUST HEADS
- Buffalo Forge Co.
- Crane Co.
- Hirschman, W. F., Co., Inc.
- Illinois Engineering Co.
- Kieley & Mueller, Inc.
- McAlear Mfg. Co.
- Patterson-Kelley Co.
- Skinner Bros. Mfg. Co., Inc.
- Sturtevant, B. F., Co.
- Swartwout Co., The

EXHAUST SYSTEMS
- American Blower Corp.
- Bayley Blower Co.
- Bentz Engineering Corp.
- Buckeye Blower Co., The
- Buffalo Forge Co.
- Carrier Engineering Corp.
- Clarage Fan Co.
- Cooling and Air Conditioning Corp.
- Garden City Fan Co.
- Hirschman, W. F., Co., Inc.
- Ilg Electric Ventilating Co.
- Johnson Fan & Blower Co.
- New York Blower Co.
- Niagara Blower Co.
- Skinner Bros. Mfg. Co., Inc.
- Sturtevant, B. F., Co.
- Wing, L. J., Mfg. Co.

EXPANSION JOINTS (*See Joints, Expansion*)

FANS—Blower (*See Blowers, Fan*)

Booster
- American Blower Corp.
- Bayley Blower Co.
- Buckeye Blower Co., The
- Buffalo Forge Co.
- Clarage Fan Co.
- De Bothezat Impeller Co.
- Garden City Fan Co.
- General Electric Co.
- Ilg Electric Ventilating Co.
- Langenberg Mfg. Co.
- Reed Air Filter Co.
- Sturtevant, B. F., Co.
- Wing, L. J., Mfg. Co.

Cooling Tower
- American Blower Corp.
- Bayley Blower Co.
- Buffalo Forge Co.
- Garden City Fan Co.

Exhaust
- American Blower Corp.
- Bayley Blower Co.
- Bishop & Babcock Sales Co., The
- Buckeye Blower Co., The
- Buffalo Forge Co.
- Clarage Fan Co.
- De Bothezat Impeller Co.
- Garden City Fan Co.
- Hirschman, W. F., Co., Inc.
- Ilg Electric Ventilating Co.
- Johnson Fan & Blower Co.
- Langenberg Mfg. Co.
- New York Blower Co.
- Niagara Blower Co.
- Peerless Unit Ventilation Co., Inc.
- Skinner Bros. Mfg. Co., Inc
- Sturtevant, B. F., Co.
- Trane Co., The
- Wing, L. J., Mfg. Co.
- York Heating & Ventilating Corp.

Ventilating
- American Blower Corp.
- Bayley Blower Co.
- Bishop & Babcock Sales Co., The
- Buckeye Blower Co., The
- Buffalo Forge Co.
- Clarage Fan Co.
- De Bothezat Impeller Co.
- Garden City Fan Co.
- General Electric Co.
- Hirschman, W. F., Co., Inc.
- Ilg Electric Ventilating Co.
- Johnson Fan & Blower Co.
- Langenberg Mfg. Co.
- New York Blower Co.
- Niagara Blower Co.

Catalogue Data of Manufacturers listed can be located by referring to pages 841 to 844

Peerless Unit Ventilation Co., Inc.
Shipp, C. C., & Co.
Skinner Bros. Mfg. Co., Inc.
Stickle Steam Specialties Co.
Sturtevant, B. F., Co.
Trane Co., The
Wing, L. J., Mfg. Co.
York Heating & Ventilating Corp.

FEEDERS (*See Boiler Feeders*)

Boiler
American Radiator Co.
Crane Co.
Economy Pumping Machinery Co.
Kieley & Mueller, Inc.
McAlear Mfg. Co., The
McDonnell & Miller
Mueller Steam Specialty Co., Inc.
Swartwout Co., The

Water
American Gas Products Corp.
American Radiator Co.
Economy Pumping Machinery Co.
Finn Pump, M. J., Mfg. Co.
Kieley & Mueller, Inc.
McDonnell & Miller
Mueller Steam Specialty Co., Inc.

FILTERS—Air
American Blower Corp.
Bayley Blower Co.
General Air Filters Corp.
Midwest Air Filters, Inc.
National Air Filter Co.
Reed Air Filter Co., Inc.
Sturtevant, B. F., Co.
Whiting Corp.

FIRE BRICK CEMENT (*See Cement, Fire Brick*)

FITTINGS—Cast Iron
Crane Co.
Grinnell Co., Inc.
Stockham Pipe & Fittings Co.

Flanged
American District Steam Co.
Crane Co.
Grinnell Co., Inc.
Stockham Pipe & Fittings Co.

Furnace
Langenberg Mfg. Co.

Malleable
Crane Co.
Grinnell Co., Inc.
Stockham Pipe & Fittings Co.

Pipe
Crane Co.
Grinnell Co., Inc.

Steel
Crane Co.
Stockham Pipe & Fittings Co.

FLANGES—Cast Iron
Crane Co.
Stockham Pipe & Fittings Co.

Steel
Stockham Pipe & Fittings Co.

FLUES—Steel
Bigelow Co., The

FOG ELIMINATORS
American Blower Corp.
Bayley Blower Co.
Bentz Engineering Corp.
Cooling and Air Conditioning Corp.
Ilg Electric Ventilating Co.
Niagara Blower Co.
Sturtevant, B. F., Co.
Wing, L. J., Mfg. Co.
York Heating & Ventilating Corp.

FORCED DRAFT
Buffalo Forge Co.
Combustion Specialties Corp.
Sturtevant, B. F., Co.
Wing, L. J., Mfg. Co.

FURNACE CEMENT
Insulating Products Corp.
Johns-Manville Corp.

FURNACES—Automatic
American Foundry & Furnace Co.
New York Blower Co.

Electric
General Electric Co.

Filters
General Air Filters Corp.
Reed Air Filter Co.

Gas
American Gas Products Corp.

Insulation
Armstrong Cork & Insulation Co.
Banner Rock Products Co.
Insulating Products Corp.
Johns-Manville Corp.

Pipeless
American Radiator Co. (Fox Furnace Div.)
Langenberg Mfg. Co.
National Radiator Corp.
New York Blower Co.
Thatcher Co., The

Warm Air
American Foundry & Furnace Co.
American Gas Products Corp.
Ilg Electric Ventilating Co.
Langenberg Mfg. Co.
National Radiator Corp.
New York Blower Co.
Richardson & Boynton Co.
Sturtevant, B. F., Co.
Thatcher Co., The

GAGE—Boards
Bishop & Babcock Sales Co., The
Consolidated Ashcroft Hancock Co., Inc. (American Schaeffer & Budenberg Div.)
Marsh, Jas. P., & Co.
Warren Webster & Co.

Cocks (*See Cocks, Gage*)

Glasses (*See Glasses, Gage*)

Siphons (*See Siphons, Gage*)

Valves (*See Valves, Gage*)

GAGES—Draft
Combustion Specialties Corp.
Consolidated Ashcroft Hancock Co., Inc. (American Schaeffer & Budenberg Div.)
Ellison Draft Gage Co.
Higgin Mfg. Co.
Hill, E. Vernon, Co.
Hoffman Specialty Co., Inc.
Taylor Instrument Cos.

Compound
American District Steam Co.
Consolidated Ashcroft Hancock Co., Inc. (American Schaeffer & Budenberg Div.)
Hoffman Specialty Co., Inc.
Sterling Engineering Co.
Trane Co., The

Hot Water
Consolidated Ashcroft Hancock Co., Inc. (American Schaeffer & Budenberg Div.)
D. & T. Mfg. Co.
Kainer & Co.
Marsh, Jas. P., & Co.
Thrush, H. A., & Co.

Pressure
Bishop & Babcock Sales Co., The
Consolidated Ashcroft Hancock Co., Inc. (American Schaeffer & Budenberg Div.)
Dunham, C. A., Co.
Kainer & Co.
Marsh, Jas. P., & Co.
O-E Specialty Mfg. Co.
Pierce, Butler & Pierce Mfg. Corp.
Sterling Engineering Co.
Taylor Instrument Cos.
Thrush, H. A., & Co.
Trane Co., The
U. S. Radiator Corp.
Warren Webster & Co.

Steam
American Radiator Co.
Burnham Boiler Corp.
Consolidated Ashcroft Hancock Co., Inc. (American Schaeffer & Budenberg Div.)
Dunham, C. A., Co.
Haines, William S., & Co.
Hoffman Specialty Co., Inc.
Marsh, Jas. P., & Co.
Pierce, Butler & Pierce Mfg. Corp.
Sterling Engineering Co.
Trane Co., The
U. S. Radiator Corp.
Warren Webster & Co.

Vacuum
American Radiator Co.
Bishop & Babcock Sales Co., The
Burnham Boiler Corp.
Consolidated Ashcroft Hancock Co., Inc. (American Schaeffer & Budenberg Div.)
Dunham, C. A., Co.
Finn Pump, M. J., Mfg. Co.
Haines, William S., & Co.
Hoffman Specialty Co., Inc.
Illinois Engineering Co.
Kainer & Co.
Marsh, Jas. P., & Co.
O-E Specialty Mfg. Co
Pierce, Butler & Pierce Mfg. Co.

Catalogue Data of Manufacturers listed can be located by referring to pages 841 to 844

Richardson & Boynton Co.
Sterling Engineering Co.
Taylor Instrument Cos.
Trane Co., The
U. S. Radiator Corp.
Warren Webster & Co.

Water
American Radiator Co.
Burnham Boiler Corp.
Consolidated Ashcroft Hancock Co., Inc. (American Schaeffer & Budenberg Div.)
Crane Co.
Finn Pump, M. J., Mfg. Co.
Marsh, Jas. P., & Co.
National Radiator Corp.
New York Air Valve Corp.
Pierce, Butler & Pierce Mfg. Corp.
Richardson & Boynton Co.
U. S. Radiator Corp.
Wright-Austin Co.

Furnaces (*See Furnaces, Gas*)

Heaters—Room (*See Heaters, Gas*)

Heating Systems (*See Heating Systems, Gas*)

Water Heaters
Alberger Heater Co.
American District Steam Co.
American Radiator Co.
Burnham Boiler Corp.
Davis Engineering Corp.
Frank, O. E., Heater & Engineering Co., Inc.
General Air Filters Corp.
Herbert Boiler Co.
Leader Iron Works
Monitor Boiler Co.
Page, Wm. H., Boiler Co.
Richardson & Boynton Co.
Smith, H. B., Co., The
Stickle Steam Specialties Co.
Swartwout Co., The
Thatcher Co., The
U. S. Radiator Corp.
Weil-McLain Co.

GASKETS—Asbestos
Crane Co.
Jenkins Bros.
Johns-Manville Corp.
McCord Radiator & Mfg. Co.

Boiler
Johns-Manville Corp.

Metallic
Johns-Manville Corp.
McCord Radiator & Mfg. Co.

Rubber
Jenkins Bros.
Johns-Manville Corp.

GATES—Blast
American Blower Corp.
Buffalo Forge Co.
Clarage Fan Co.
Garden City Fan Co.
New York Blower Co.
Sturtevant, B. F., Co.

GENERATOR COOLING SYSTEMS
American Blower Corp.
Bayley Blower Co.
Bentz Engineering Corp.
Buffalo Forge Co.
Carrier Engineering Corp.
Clarage Fan Co.
Cooling and Air Conditioning Corp.
Finn Pump, M. J., Mfg. Co.
General Air Filters Corp.
Niagara Blower Co.
Reed Air Filter Co.
Sturtevant, B. F., Co.

Generating Equipment
General Electric Co.
Sturtevant, B. F., Co.

GENERATORS—Electric
General Electric Co.
Sturtevant, B. F., Co.

Heat (*See Boilers, Furnaces and Heaters*)

Hot-Water
Alberger Heater Co.
American Gas Products Corp.
American Radiator Co.
Burnham Boiler Corp.
D. & T. Mfg. Co.
Davis Engineering Corp.
Excelso Products Corp.
Finn Pump, M. J., Mfg. Co.
Frank, O. E., Heater & Engineering Co., Inc.
General Air Filters Corp.
Herbert Boiler Co.
Leader Iron Works
Mueller Co.
Page, Wm. H., Boiler Co.
Patterson-Kelley Co.
Whitlock Coil Pipe Co.

Turbines
General Electric Co.
Sturtevant, B. F., Co.

Vacuum
Dunham, C. A., Co.
Finn Pump, M. J., Mfg. Co.
Haines, Wm. S., & Co.
Illinois Engineering Co.
Kieley & Mueller, Inc.
McAlear Mfg. Co.
O-E Specialty Mfg. Co.
Sarco Co., Inc.
Sterling Engineering Co.
Stickle Steam Specialties Co.
Trane Co., The

GLASSES—Gage
Crane Co.
Jenkins Bros.
O-E Specialty Mfg. Co.

GOVERNORS—Condensation
Davis, G. M., Regulator Co.
Dunham, C. A., Co.
Kieley & Mueller, Inc.
Klipfel Mfg. Co.
Mason Regulator Co.
McAlear Mfg. Co.
Mueller Steam Specialty Co., Inc.
Swartwout Co., The
Warren Webster & Co.

Pressure
Kainer & Co.

Pump (*See Regulators, Pump*)

Vacuum (*See Regulators, Vacuum*)

GRATES—Dumping
Fitzgibbons Boiler Co., Inc.
Frost Mfg. Co., The
Oil City Boiler Works

Rocking
Frost Mfg. Co., The
Herbert Boiler Co.
Kewanee Boiler Corp.
Oil City Boiler Works

Shaking
Frost Mfg. Co., The
Herbert Boiler Co.
Kewanee Boiler Corp.
Oil City Boiler Works
Titusville Iron Works Co., The

GRILLES AND REGISTERS (*See Registers and Grilles*)

HANGERS—Adjustable Pipe
Clip-Bar Mfg. Co.
Crane Co.
Fitzgibbons Boiler Co., Inc.
Grinnell Co., Inc.
Smith, H. B., Co., The

Pipe
Clip-Bar Mfg. Co.
Crane Co.
Grinnell Co., Inc.
Kewanee Boiler Corp.
Midwest Air Filters, Inc.
National Radiator Corp.
Pierce, Butler & Pierce Mfg. Corp.
York Heating & Ventilating Corp.

Radiator
American Foundry & Furnace Co.
American Radiator Co.
Burnham Boiler Corp.
Clip-Bar Mfg. Co.
Copper Radiator Sales Corp.
Grinnell Co., Inc.
Healy-Ruff Co.
Kewanee Boiler Corp.
Little Giant Mfg. Co., The
McAlear Mfg. Co., The
National Radiator Corp.
Pierce, Butler & Pierce Mfg. Corp.
Smith, H. B., Co., The
Sterling Engineering Co.
Thatcher Co., The
U. S. Radiator Corp.

HEADERS
Alberger Heater Co.
Crane Co.
General Air Filters Corp.
Grinnell Co., Inc.

HEAT EXCHANGERS
Aerofin Corp.
Alberger Heater Co.
American Blower Corp.
Buffalo Forge Co.
Carrier Engineering Corp.
Clarage Fan Co.
Crane Co.
Davis Engineering Corp.

Catalogue Data of Manufacturers listed can be located by referring to pages 841 to 844

Excelso Products Corp.
Frank, O. E., Heater & Engineering Co., Inc.
Leader Iron Works
Patterson-Kelley Co.
Rome Brass Radiator Corp.
Schutte & Koerting Co.
Stickle Steam Specialties Co.
Sturtevant, B. F., Co.
Whitlock Coil Pipe Co.

Heat Insulating (*See Insulating*)

Regulators, Automatic

Absolute Con-tac-tor Corp.
American Radiator Co.
Sarco Co., Inc.
Webster Tallmadge & Co., Inc.

HEATERS—Air

Aerofin Corp.
American Blower Corp.
American Foundry & Furnace Co.
Bayley Blower Co.
Buckeye Blower Co., The
Buffalo Forge Co.
Circulair Heat, Inc.
Clarage Fan Co.
Copper Radiator Sales Corp.
Frank, O. E., Heater & Engineering Co., Inc.
Garden City Fan Co.
General Air Filters Corp.
General Electric Co.
Grinnell Co., Inc.
Hoffman Specialty Co., Inc.
Ilg Electric Ventilating Co.
Langenberg Mfg. Co.
Nesbitt, John J., Inc.
New York Blower Co.
Niagara Blower Co.
Peerless Unit Ventilation Co., Inc.
Rome Brass Radiator Corp.
Schutte & Koerting Co.
Shipp, C. C., & Co.
Skinner Bros. Mfg. Co., Inc.
Spencer Heater Co.
Stickle Steam Specialties Co.
Sturtevant, B. F., Co.
Trane Co., The
Warren Webster & Co.
Wing, L. J., Mfg. Co.
York Heating & Ventilating Corp.

Automatic Hot Water

American Radiator Co.
Bell & Gossett Co.
Crane Co.
Davis Engineering Corp.
Excelso Products Corp.
Ilg Electric Ventilating Co.
Kainer & Co.
Kewanee Boiler Corp.
Leader Iron Works
Mueller Co.
Neptune Meter Co.

Blast

Aerofin Corp.
American Blower Corp.
American Foundry & Furnace Co.
American Radiator Co.
Bayley Blower Co.
Buckeye Blower Co., The
Buffalo Forge Co.
Clarage Fan Co.
Garden City Fan Co.
Ilg Electric Ventilating Co.
New York Blower Co.
Niagara Blower Co.
Peerless Unit Ventilation Co., Inc.
Rome Brass Radiator Corp.
Rome-Turney Radiator Co., The
Schutte & Koerting Co.
Skinner Bros. Mfg. Co., Inc.
Stickle Steam Specialties Co.
Sturtevant, B. F., Co.
Trane Co., The
Wing, L. J., Mfg. Co.
York Heating & Ventilating Corp.

Cabinet

Buckeye Blower Co., The
Circulair Heat, Inc.
Copper Radiator Sales Corp.
Rome Brass Radiator Corp.
Sturtevant, B. F., Co.
Trane Co., The
Tuttle & Bailey Mfg. Co.

Combination, Water and Steam with Warm Air

American Foundry & Furnace Co

Electric (*Air*)

Hoffman Specialty Co., Inc.

Fan System

Aerofin Corp.
American Blower Corp.
American Foundry & Furnace Co.
Bayley Blower Co.
Buckeye Blower Co., The
Buffalo Forge Co.
Clarage Fan Co.
De Bothezat Impeller Co.
Garden City Fan Co.
Ilg Electric Ventilating Co.
Johnson Fan & Blower Co.
Langenberg Mfg. Co.
New York Blower Co.
Niagara Blower Co.
Peerless Unit Ventilation Co., Inc.
Rome Brass Radiator Corp.
Rome-Turney Radiator Co., The
Schutte & Koerting Co.
Skinner Bros. Mfg. Co., Inc.
Stickle Steam Specialties Co.
Sturtevant, B. F., Co.
Trane Co., The
Wing, L. J., Mfg. Co.
York Heating & Ventilating Corp.

Feed Water

Alberger Heater Co.
Davis Engineering Corp.
Finn Pump, M. J., Mfg. Co.
Frank, O. E., Heater & Engineering Co., Inc.
Frost Mfg. Co., The
Patterson-Kelley Co.
Rome Brass Radiator Corp.
Stickle Steam Specialties Co.
Sturtevant, B. F., Co.
Swartwout Co., The
Whitlock Coil Pipe Co.

Fuel Oil

Petroleum Heat & Power Co.

Gas

American Gas Products Corp.
American Radiator Co.
Clarage Fan Co.
Crane Co.

Hot Water Service

Alberger Heater Co.
American Gas Products Corp.
American Radiator Co.
Badger, E. B., & Sons Co.
Bell & Gossett Co.
Burnham Boiler Corp.
Crane Co.
Davis Engineering Corp.
Excelso Products Corp.
Finn Pump, M. J., Mfg. Co.
Frank, O. E., Heater & Engineering Co., Inc.
Frost Mfg. Co., The
Heggie-Simplex Boiler Co.
Kewanee Boiler Corp.
Leader Iron Works
Molby Boiler Co., Inc.
Monitor Boiler Co.
Neptune Meter Co.
Oil City Boiler Works
Page, Wm. H., Boiler Co.
Patterson-Kelley Co.
Richardson & Boynton Co.
Rome Brass Radiator Corp.
Smith, H. B., Co., The
Spencer Heater Co.
Thatcher Co., The
Titusville Iron Works Co., The
U. S. Radiator Corp.
Weil-McLain Co.
Whitlock Coil Pipe Co.

Indirect

Aerofin Corp.
American Blower Corp.
American Gas Products Corp.
Bayley Blower Co.
Bell & Gossett Co.
Buckeye Blower Co., The
Buffalo Forge Co.
Clarage Fan Co.
Copper Radiator Sales Corp.
Davis Engineering Corp.
Excelso Products Corp.
General Air Filters Corp.
Ilg Electric Ventilating Co.
Newport Boiler Co.
Niagara Blower Co.
Patterson-Kelley Co.
Peerless Unit Ventilation Co., Inc.
Rome Brass Radiator Corp.
Schutte & Koerting Co.
Shipp, C. C., & Co.
Skinner Bros. Mfg. Co., Inc.
Smith, H. B., Co., The
Stickle Steam Specialties Co.
Sturtevant, B. F., Co.
Trane Co., The
Whitlock Coil Pipe Co.
York Heating & Ventilating Corp.

Industrial

American Gas Products Corp.
American Blower Corp.
Bayley Blower Co.
Buckeye Blower Co., The
Buffalo Forge Co.
Clarage Fan Co.
Copper Radiator Sales Corp.
Davis Engineering Corp.
Finn Pump, M. J., Mfg. Co.
Garden City Fan Co.
General Air Filters Corp.
General Electric Co.
Grinnell Co., Inc.
Ilg Electric Ventilating Co.
Johnson Fan & Blower Co.
Langenberg Mfg. Co.
New York Blower Co.
Niagara Blower Co.
Patterson-Kelley Co.
Peerless Unit Ventilation Co., Inc.
Rome Brass Radiator Corp.
Skinner Bros. Mfg. Co., Inc.

Catalogue Data of Manufacturers listed can be located by referring to pages 841 to 844

Stickle Steam Specialties Co.
Sturtevant, B. F., Co.
Trane Co., The
Wing, L. J., Mfg. Co.
York Heating & Ventilating Corp.

Instantaneous Hot Water

Alberger Heater Co.
Bell & Gossett Co.
Davis Engineering Corp.
Frank, O. E., Heater & Engineering Co., Inc.
General Air Filters Corp.
Patterson-Kelley Co.
Powers Regulator Co.
Whitlock Coil Pipe Co.

Oil

Clarage Fan Co.

Room

American Blower Corp.
American Radiator Co.
Bayley Blower Co.
Buckeye Blower Co., The
Buffalo Forge Co.
Circulair Heat, Inc.
Clarage Fan Co.
Copper Radiator Sales Corp.
Finn Pump, M. J., Mfg. Co.
General Air Filters Corp.
Hoffman Specialty Co., Inc.
Ilg Electric Ventilating Co.
Langenberg Mfg. Co.
Rome Brass Radiator Corp.
Sturtevant, B. F., Co.
Thatcher Co., The
Trane Co., The

School (*See Room*)

Tank

Alberger Heater Co.
American District Steam Co.
American Radiator Co.
Badger, E. B., & Sons Co.
Burnham Boiler Corp.
Davis Engineering Corp.
Excelso Products Corp.
Frank, O. E., Heater & Engineering Co., Inc.
Herbert Boiler Co.
Kewanee Boiler Corp.
Leader Iron Works
Molby Boiler Co., Inc.
National Radiator Corp.
Neptune Meter Co.
Page, Wm. H., Boiler Co.
Patterson-Kelley Co.
Richardson & Boynton Co.
Smith, H. B., Co., The
Spencer Heater Co.
Thatcher Co., The
Thrush, H. A., & Co.
Titusville Iron Works Co., The
U. S. Radiator Corp.
Weil-McLain Co.
Whitlock Coil Pipe Co.

Unit

Aerofin Corp.
American Blower Corp.
American Foundry & Furnace Co.
Bayley Blower Co.
Bentz Engineering Corp.
Bishop & Babcock Sales Co., The
Buckeye Blower Co., The
Buffalo Forge Co.
Circulair Heat, Inc.
Clarage Fan Co.
Copper Radiator Sales Corp.
Garden City Fan Co.
General Air Filters Corp.
Grinnell Co., Inc.
Ilg Electric Ventilating Co.
Johnson Fan & Blower Co.
Langenberg Mfg. Co.
McQuay Radiator Corp.
Herman Nelson Corp.
Nesbitt, John J., Inc.
New York Blower Co.
Niagara Blower Co.
Peerless Unit Ventilation Co., Inc.
Rome Brass Radiator Corp.
Rome-Turney Radiator Co., The
Schutte & Koerting Co.
Shipp, C. C., & Co.
Skinner Bros. Mfg. Co., Inc.
Stickle Steam Specialties Co.
Sturtevant, B. F., Co.
Thermidaire Corp.
Trane Co., The
Wing, L. J., Mfg. Co.
York Heating & Ventilating Corp.

Wall Type

Bayley Blower Co.
Buckeye Blower Co., The
Circulair Heat, Inc.
Sturtevant, B. F., Co.
Trane Co., The

Water (*Garbage Burner*)

Heggie-Simplex Boiler Co.
Herbert Boiler Co.
Kewanee Boiler Corp.
Oil City Boiler Works

Water (*Incinerator*)

Alberger Heater Co.
Finn Pump, M. J., Mfg. Co.
General Air Filters Corp.
Heggie-Simplex Boiler Co.
Kewanee Boiler Corp.
Oil City Boiler Works

HEATING AND VENTILATING APPARATUS

Aerofin Corp.
American Blower Corp.
American Foundry & Furnace Co.
American Gas Products Corp.
American Radiator Co.
Armstrong Machine Works
Barnes & Jones
Bayley Blower Co.
Bishop & Babcock Sales Co., The
Buckeye Blower Co., The
Buffalo Forge Co.
Burnham Boiler Corp.
Carrier Air Conditioning Corp. of America
Carrier Engineering Corp.
Carrier-Lyle Corp.
Clarage Fan Co.
Coatesville Boiler Works
Combustion Specialties Corp.
Cooling and Air Conditioning Corp.
Copper Radiator Sales Corp.
Crane Co.
Davis, G. M., Regulator Co.
De Bothezat Impeller Co.
Direct Control Valve Co.
Dunham, C. A., Co.
Edge Moor Iron Co.
Finn Pump, M. J., Mfg. Co.
Fitzgibbons Boiler Co., Inc.
Garden City Fan Co.
General Air Filters Corp.
Grinnell Co., Inc.
Haines, William S., & Co.
Heggie-Simplex Boiler Co.
Herbert Boiler Co.
Hirschman, W. F., Co., Inc.
Hoffman Specialty Co., Inc.
Ilg Electric Ventilating Co.
Illinois Engineering Co.
Johnson Fan & Blower Co.
Kainer & Co.
Kelly Brass Works
Kewanee Boiler Corp.
Kieley & Mueller, Inc.
Klipfel Mfg. Co.
Langenberg Mfg. Co.
Leader Iron Works
Marsh, Jas. P., & Co.
Mason Regulator Co.
McCord Radiator & Mfg. Co.
McQuay Radiator Corp.
Midwest Air Filters, Inc.
Nash Engineering Co.
National Air Filter Co.
National Radiator Corp.
National Regulator Co.
Neptune Meter Co.
Newport Boiler Co.
New York Air Valve Corp.
New York Blower Co.
Niagara Blower Co.
O-E Specialty Mfg. Co.
Page, Wm. H., Boiler Co.
Peerless Unit Ventilation Co., Inc.
Prox, Frank, Co.
Reed Air Filter Co.
Richmond Radiator Co.
Rome Brass Radiator Corp.
Sarco Co., Inc.
Schutte & Koerting Co.
Shipp, C. C., & Co.
Skinner Bros. Mfg. Co., Inc.
Smith, H. B., Co., The
Smith Twin Tubular Boiler Co.
Spencer Heater Co.
Stanwood Corp., The
Sterling Engineering Co.
Stickle Steam Specialties Co.
Sturtevant, B. F., Co.
Swartwout Co., The
Webster Tallmadge & Co., Inc.
Thatcher Co., The
Titusville Iron Works Co., The
Trane Co., The
Tuttle & Bailey Mfg. Co.
U. S. Radiator Corp.
Vapor Engineering Co., Inc.
Warren Webster & Co.
Weil-McLain Co.
Wing, L. J., Mfg. Co.
York Heating & Ventilating Corp.

HEATING SPECIALTIES

Absolute Con-tac-tor Corp.
American Blower Corp.
American District Steam Co.
American Foundry & Furnace Co.
American Gas Products Corp.
American Radiator Co.
Armstrong Machine Works
Barnes & Jones
Bishop & Babcock Sales Co., The
Buffalo Forge Co.
Burnham Boiler Corp.
Clarage Fan Co.
Combustion Specialties Corp.
Consolidated Aschroft Hancock Co., Inc. (American Schaeffer & Budenberg Div.)
Crane Co.
Davis Engineering Corp.
Davis, G. M., Regulator Co.

Catalogue Data of Manufacturers listed can be located by referring to pages 841 to 844

Direct Control Valve Co.
Dole Valve Co., The
Dunham, C. A., Co.
General Air Filters Corp.
Grinnell Co., Inc.
Haines, William S., & Co.
Healy-Ruff Co.
Hoffman Specialty Co., Inc.
Ilg Electric Ventilating Co.
Illinois Engineering Co.
Johns-Manville Corp.
Kainer & Co.
Kieley & Mueller, Inc.
Klipfel Mfg. Co.
Marine-Galligan Co., Inc.
Marsh, Jas. P., & Co.
Mason Regulator Co.
McAlear Mfg. Co.
McDonnell & Miller
Monash-Younker Co., Inc.
Mueller Steam Specialty Co., Inc.
Nash Engineering Co.
National Radiator Corp.
National Regulator Co.
Newport Boiler Co.
New York Air Valve Corp.
O-E Specialty Mfg. Co.
Page, Wm. H., Boiler Co.
Peerless Unit Ventilation Co., Inc.
Petroleum Heat & Power Co.
Powers Regulator Co.
Russell, W. A., & Co.
Sarco Co., Inc.
Sterling Engineering Co.
Stickle Steam Specialties Co.
Sturtevant, B. F., Co.
Webster Tallmadge & Co., Inc.
Trane Co., The
U. S. Radiator Corp.
Vapor Engineering Co., Inc.
Warren Webster & Co.

HEATING SYSTEMS—Gas

American Blower Corp.
American Foundry & Furnace Co.
American Gas Products Corp.
Barnes & Jones
Carrier Engineering Corp.
Carrier-Lyle Corp.
Circulair Heat, Inc.
Clarage Fan Co.
Coatesville Boiler Works
Cooling & Air Conditioning Corp.
Dunham, C. A., Co.
Edge Moor Iron Co.
Finn Pump, M. J., Mfg. Co.
Garden City Fan Co.
Hoffman Specialty Co., Inc.
Ilg Electric Ventilating Co.
Marsh, James P., & Co.
McAlear Mfg. Co.
Mueller Co.
Neptune Meter Co.
Newport Boiler Co.
New York Blower Co.
O-E Specialty Mfg. Co.
Sarco Co., Inc.
Spencer Heater Co.
Sturtevant, B. F., Co.
Webster Tallmadge & Co., Inc.
Trane Co., The
Vapor Engineering Co., Inc.
Warren Webster & Co.

Hot Blast

Aerofin Corp.
American Blower Corp.
American Foundry & Furnace Co.
American Radiator Co.
Bayley Blower Co.
Bishop & Babcock Sales Co., The
Buckeye Blower Co., The
Buffalo Forge Co.
Carrier Engineering Corp.
Clarage Fan Co.
Cooling and Air Conditioning Corp.
De Bothezat Impeller Co.
Garden City Fan Co.
Ilg Electric Ventilating Co.
Langenberg Mfg. Co.
New York Blower Co.
Niagara Blower Co.
O-E Specialty Mfg. Co.
Peerless Unit Ventilation Co., Inc.
Rome Brass Radiator Corp.
Schutte & Koerting Co.
Skinner Bros. Mfg. Co., Inc.
Stickle Steam Specialties Co.
Sturtevant, B. F., Co.
Thatcher Co., The
Trane Co., The
Wing, L. J., Mfg. Co.
York Heating & Ventilating Corp.

Hot Water

American Blower Corp.
American Gas Products Corp.
American Radiator Co.
Barnes & Jones
Bell & Gossett Co.
Buffalo Forge Co.
Burnham Boiler Corp.
Clarage Fan Co.
Copper Radiator Sales Corp.
D. & T. Mfg. Co.
Davis Engineering Corp.
Finn Pump, M. J., Mfg. Co.
Fitzgibbons Boiler Co.
Frost Mfg. Co., The
Ilg Electric Ventilating Co.
Kainer & Co.
Kewanee Boiler Corp.
Leader Iron Works
Monitor Boiler Co.
Mueller Co.
National Radiator Corp.
Neptune Meter Co.
Newport Boiler Co.
Page, Wm. H., Boiler Co.
Patterson-Kelley Co.
Prox, Frank, Co.
Richardson & Boynton Co.
Richmond Radiator Co.
Rome Brass Radiator Corp.
Sarco, Inc.
Smith, H. B., Co., The
Spencer Heater Co.
Stanwood Corp., The
Thatcher Co., The
Thrush, H. A., & Co.
Titusville Iron Works Co., The
Trane Co., The
U. S. Radiator Corp.
York Heating & Ventilating Corp.

Steam

American Blower Corp.
American District Steam Co.
American Gas Products Corp.
American Radiator Co.
Barnes & Jones
Bishop & Babcock Sales Co., The
Buckeye Blower Co., The
Buffalo Forge Co.
Burnham Boiler Corp.
Carrier Engineering Corp.
Circulair Heat, Inc.
Clarage Fan Co.
Cooling and Air Conditioning Corp.
Copper Radiator Sales Corp.
Davis Engineering Corp.
Dunham, C. A., Co.
Edge Moor Iron Co.
Finn Pump, M. J., Mfg. Co.
Fitzgibbons Boiler Co.
Frost Mfg. Co., The
Haines, William S., & Co.
Hoffman Specialty Co., Inc.
Ilg Electric Ventilating Co.
Illinois Engineering Co.
Kelly Brass Works
Kewanee Boiler Corp.
Kieley & Mueller, Inc.
Leader Iron Works
Marsh, Jas. P., & Co.
McAlear Mfg. Co.
Monitor Boiler Co.
National Radiator Corp.
Newport Boiler Co.
Niagara Blower Co.
Page, Wm. H., Boiler Co.
Peerless Unit Ventilation Co., Inc.
Prox, Frank, Co.
Richardson & Boynton Co.
Richmond Radiator Co.
Rome Brass Radiator Corp.
Sarco Co., Inc.
Skinner Bros. Mfg. Co., Inc.
Smith, H. B., Co., The
Smith Twin Tubular Boiler Co.
Spencer Heater Co.
Stanwood Corp., The
Sterling Engineering Co.
Stickle Steam Specialties Co.
Sturtevant, B. F., Co.
Webster Tallmadge & Co., Inc.
Thatcher Co., The
Titusville Iron Works Co., The
Trane Co., The
U. S. Radiator Corp.
Warren Webster & Co.
Wing, L. J., Mfg. Co.
York Heating & Ventilating Corp.

Steam (*Differential Vacuum*)

Dunham, C. A., Co.

Steam (*Exhaust*)

American Blower Corp.
American District Steam Co.
Barnes & Jones
Bishop & Babcock Sales Co., The
Buckeye Blower Co., The
Buffalo Forge Co.
Carrier Engineering Corp.
Clarage Fan Co.
Cooling and Air Conditioning Corp.
Copper Radiator Sales Corp.
Davis Engineering Corp.
Dunham, C. A., Co.
Finn Pump, M. J., Mfg. Co.
Haines, William S., & Co.
Hoffman Specialty Co., Inc.
Ilg Electric Ventilating Co.
Illinois Engineering Co.
Kieley & Mueller, Inc.
Leader Iron Works
Marine-Galligan Co., Inc.
Marsh, Jas. P., & Co.
McAlear Mfg. Co.
Niagara Blower Co.
Page, Wm. H., Boiler Co.
Patterson-Kelley Co.
Peerless Unit Ventilation Co., Inc
Rome Brass Radiator Corp.
Sarco Co., Inc.
Skinner Bros. Mfg. Co., Inc.
Smith, H. B., Co., The
Stickle Steam Specialties Co.
Sturtevant, B. F., Co.

Catalogue Data of Manufacturers listed can be located by referring to pages 841 to 844

Webster Tallmadge & Co., Inc.
Trane Co., The
Warren Webster & Co.
Wing, L. J., Mfg. Co.
York Heating & Ventilating Corp.

Steam (*Vacuum*)

American Blower Corp.
American District Steam Co.
American Gas Products Corp.
Barnes & Jones
Bishop & Babcock Sales Co., The
Buckeye Blower Co., The
Burnham Boiler Corp.
Carrier Engineering Corp.
Circulair Heat, Inc.
Clarage Fan Co.
Cooling and Air Conditioning Corp.
Copper Radiator Sales Corp.
Dunham, C. A., Co.
Finn Pump, M. J., Mfg. Co.
Haines, William S., & Co.
Hoffman Specialty Co., Inc.
Ilg Electric Ventilating Co.
Illinois Engineering Co.
Kelly Brass Works
Kewanee Boiler Corp.
Kieley & Mueller, Inc.
Leader Iron Works
Marine-Galligan Co., Inc.
Marsh, Jas. P., & Co.
McAlear Mfg. Co.
Monash-Younker Co.
Mueller Co.
Nash Engineering Co.
Newport Boiler Co.
Niagara Blower Co.
O-E Specialty Mfg. Co.
Page, Wm. H., Boiler Co
Peerless Unit Ventilation Co., Inc.
Rome Brass Radiator Corp.
Sarco Co., Inc.
Skidmore Corp.
Skinner Bros. Mfg. Co., Inc.
Smith, H. B., Co., The
Smith Twin Tubular Boiler Co.
Spencer Heater Co.
Sterling Engineering Co.
Stickle Steam Specialties Co.
Sturtevant, B. F., Co.
Webster Tallmadge & Co., Inc.
Trane Co., The
U. S. Radiator Corp.
Vapor Engineering Co., Inc.
Warren Webster & Co.
Wing, L. J., Mfg. Co.
York Heating & Ventilating Corp.

Steam (*Vapor*)

American District Steam Co.
American Gas Products Corp.
Barnes & Jones
Bishop & Babcock Sales Co., The
Burnham Boiler Corp.
Carrier Engineering Corp.
Circulair Heat, Inc.
Cooling and Air Conditioning Corp.
Copper Radiator Sales Corp.
Dunham, C. A., Co.
Finn Pump, M. J., Mfg. Co.
Haines, William S., & Co.
Hoffman Specialty Co., Inc.
Illinois Engineering Co.
Kewanee Boiler Corp.
Kieley & Mueller, Inc.
Leader Iron Works
Marine-Galligan Co., Inc.
Marsh, Jas. P., & Co.
McAlear Mfg. Co.
Monash-Younker Co.
Monitor Boiler Co.
Newport Boiler Co.
Niagara Blower Co.
O-E Specialty Mfg. Co.
Page, Wm. H., Boiler Co.
Peerless Unit Ventilation Co., Inc.
Richardson & Boynton Co.
Rome Brass Radiator Corp.
Sarco Co., Inc.
Skinner Bros. Mfg. Co., Inc.
Smith, H. B., Co., The
Smith Twin Tubular Boiler Co.
Spencer Heater Co.
Sterling Engineering Co.
Stickle Steam Specialties Co.
Titusville Iron Works Co., The
Trane Co., The
U. S. Radiator Corp.
Vapor Engineering Co., Inc.
Warren Webster & Co.
Wing, L. J., Mfg. Co.
York Heating & Ventilating Corp.

Tank in Basement

D. & T. Mfg. Co.
Leader Iron Works
Neptune Meter Co.
Mueller Co.
Thrush, H. A., & Co.

Warm-Air

American Foundry & Furnace Co.
American Radiator Co. (Fox Furnace Div.)
Bayley Blower Co.
Buckeye Blower Co., The
Buffalo Forge Co.
Carrier Engineering Corp.
Carrier-Lyle Corp.
Clarage Fan Co.
Cooling and Air Conditioning Corp.
Copper Radiator Sales Corp.
De Bothezat Impeller Co.
Ilg Electric Ventilating Co.
Langenberg Mfg. Co.
New York Blower Co.
Richardson & Boynton Co.
Rome Brass Radiator Corp.
Skinner Bros. Mfg. Co., Inc.
Stickle Steam Specialties Co.
Sturtevant, B. F., Co.
Thatcher Co., The
Tuttle & Bailey Mfg. Co.

HOT BLAST HEATING SYSTEMS (*See Heating Systems, Hot Blast*)

HOT WATER CIRCULATING PUMPS (*See Pumps, Circulating*)

HOT WATER HEATERS, AUTOMATIC (*See Heaters, Automatic Hot Water*)

HOT WATER HEATERS, INSTANTANEOUS (*See Heaters, Instantaneous Hot Water*)

HOT WATER HEATERS, SERVICE (*See Heaters, Hot Water Service*)

HOT WATER HEATING SYSTEMS (*See Heating Systems, Hot Water*)

HYGROMETERS

Grinnell Co., Inc.
Taylor Instrument Cos.

HUMIDIFIERS

American Blower Corp.
American Radiator Co.
Atmospheric Conditioning Corp.
Bayley Blower Co.
Bentz Engineering Corp.
Bishop & Babcock Sales Co., The
Buffalo Forge Co.
Carrier Engineering Corp.
Clarage Fan Co.
Cooling and Air Conditioning Corp.
Crane Co.
Finn Pump, M. J., Mfg. Co.
General Air Filters Corp.
Grinnell Co., Inc.
Ilg Electric Ventilating Co.
Johnson Service Co.
Langenberg Mfg. Co.
McQuay Radiator Corp.
Midwest Air Filters, Inc.
National Air Filter Co.
National Regulator Co.
New York Blower Co.
Niagara Blower Co.
Powers Regulator Co.
Reed Air Filter Co.
Shipp, C. C., & Co.
Skinner Bros. Mfg. Co., Inc.
Sturtevant, B. F., Co.
Tuttle & Bailey Mfg. Co.
United States Ozone Co.
York Heating & Ventilating Corp.

Unit

Carrier Engineering Corp.
Clarage Fan Co.
Niagara Blower Co.
York Heating & Ventilating Corp.

HUMIDITY CONTROL

American Blower Corp.
Atmospheric Conditioning Corp.
Bayley Blower Co.
Bentz Engineering Corp.
Bishop & Babcock Sales Co., The
Buffalo Forge Co.
Carrier Engineering Corp.
Carrier-Lyle Corp.
Consolidated Ashcroft Hancock Co., Inc. (American Schaeffer & Budenberg Div.)
Cooling and Air Conditioning Corp.
Grinnell Co., Inc.
Ilg Electric Ventilating Co.
Johnson Service Co.
Klipfel Mfg. Co.
Midwest Air Filters, Inc.
National Regulator Co.
New York Blower Co.
Niagara Blower Co.
Powers Regulator Co.
Sarco Co., Inc.
Skinner Bros. Mfg. Co., Inc.
Sturtevant, B. F., Co.
Taylor Instrument Cos.
York Heating & Ventilating Corp.

INCINERATORS, Hot Water (*See Heaters, Water, Incinerator*)

INSERTS—Concrete

Grinnell Co., Inc.
Healy-Ruff Co.
Little Giant, Mfg. Co., The

Catalogue Data of Manufacturers listed can be located by referring to pages 841 to 844

INSTRUMENTS—Air Testing (*See Air Testing Instruments*)

Indicating
Combustion Specialties Corp.
Consolidated Ashcroft Hancock Co., Inc. (American Schaeffer & Budenberg Div.)
Ellison Draft Gage Co.
Hill, E. Vernon, Co.
Marsh, Jas. P., & Co.
Taylor Instrument Cos.

Recording
Consolidated Ashcroft Hancock Co., Inc. (American Schaeffer & Budenberg Div.)
Marsh, Jas. P., & Co.
Taylor Instrument Cos.

INSULATING MATERIALS (*See Asbestos and Insulating Products*)

Boiler
Armstrong Cork & Insulation Co.
Banner Rock Products Co.
Samuel Cabot, Inc.
Insulating Products Corp.
Johns-Manville Corp.
Sprayo-Flake Co.

Cold
Armstrong Cork & Insulation Co.
Banner Rock Products Co.
Samuel Cabot, Inc.
Celotex Co.
Flax-li-num Insulating Co.
Insulite Co., The
Johns-Manville Corp.
MacAndrews & Forbes Co.
Masonite Corp.
Pantasote Co., Inc.
Sprayo-Flake Co.
Stewart Inso Board Co.
Universal Gypsum & Lime Co.
Wood Conversion Co.

Heat
Armstrong Cork & Insulation Co.
Banner Rock Products Co.
Samuel Cabot, Inc.
Celotex Co.
Flax-li-num Insulating Co.
Insulating Products Corp.
Insulite Co., The
Johns-Manville Corp.
MacAndrews & Forbes Co.
Masonite Corp.
Pantasote Co., Inc.
Ric-wiL Co., The
Sprayo-Flake Co.
Stewart Inso Board Co.
United States Gypsum Co.
Universal Gypsum & Lime Co.
Wood Conversion Co.

Sound Deadening
Armstrong Cork & Insulation Co.
Banner Rock Products Co.
Samuel Cabot, Inc.
Celotex Co.
Flax-li-num Insulating Co.
Insulating Products Corp.
Insulite Co., The
Johns-Manville Corp.
MacAndrews & Forbes Co.
Masonite Corp.
Pantasote Co., Inc.
Sprayo-Flake Co.
Stewart Inso Board Co.
Wood Conversion Co.

JOINTS—Expansion
Alberger Heater Co.
American District Steam Co.
Badger, E. B., & Sons Co.
Crane Co.
Howard Iron Works
Illinois Engineering Co.
Johns-Manville Corp.
Mogul Machine Co.
Warren Webster & Co.

Pipe
Crane Co.
Grinnell Co., Inc.
Johns-Manville Corp.

KILNS, DRY
American Blower Corp.
Bayley Blower Co.
Buffalo Forge Co.
Carrier Engineering Corp.
Cooling and Air Conditioning Corp.
De Bothezat Impeller Co.
Finn Pump, M. J., Mfg. Co.
Garden City Fan Co.
New York Blower Co.
Sturtevant, B. F., Co.
Trane Co., The

LIQUID, BOILER (*See Boiler Liquid*)

MACHINES, REFRIGERATING (*See Refrigerating Machinery*)

MAGNESIA PRODUCTS (*See Asbestos and Insulating Products*)

MECHANICAL DRAFT APPARATUS
American Blower Corp.
Bayley Blower Co.
Buffalo Forge Co.
Carrier Engineering Corp.
Clarage Fan Co.
Combustion Specialties Corp.
De Bothezat Impeller Co.
Garden City Fan Co.
Ilg Electric Ventilating Co.
Kieley & Mueller, Inc.
Mason Regulator Co.
National Regulator Co.
New York Blower Co.
Sturtevant, B. F., Co.
Wing, L. J., Mfg. Co.

METAL WEATHER STRIPS (*See Weather Strips, Metal*)

METERS—Air
Builders Iron Foundry

Condensation
American District Steam Co.
Builders Iron Foundry

Electric
General Electric Co.

Feed Water
Builders Iron Foundry

Flow
American District Steam Co.
Builders Iron Foundry

Gas
Builders Iron Foundry

Water
Builders Iron Foundry
Finn Pump, M. J., Mfg. Co.
Johns-Manville Corp.
Neptune Meter Co.

MIXERS, WATER (*Thermostatic*)
Finn Pump, M. J., Mfg. Co.

MOISTENERS, AIR (*See Humidifiers*)

MOTOR CONTROLLERS (*See Controllers, Motor*)

MOTORS—Electric
General Electric Co.
Ilg Electric Ventilating Co.
Johnson Service Co.
Sturtevant, B. F., Co.

MUSHROOM VENTILATORS (*See Ventilators, Mushroom*)

NOZZLES—Brine Spray
Atmospheric Conditioning Corp.
Badger, E. B., & Sons Co.
Bayley Blower Co.
Buffalo Forge Co.
Finn Pump, M. J., Mfg. Co.
General Air Filters Corp.

Spray
American Blower Corp.
Atmospheric Conditioning Corp.
Badger, E. B., & Sons Co.
Bayley Blower Co.
Buffalo Forge Co.
Clarage Fan Co.
Cooling and Air Conditioning Corp.
Finn Pump, M. J., Mfg. Co.
General Air Filters Corp.
Jenkins Bros.
New York Blower Co.
Sturtevant, B. F., Co.

OIL BURNERS
Automatic Burner Corp.
Ballard Oil Equipment Co.
Hardinge Brothers, Inc.
May Oil Burner Corp.
Petroleum Heat & Power Co.
Winslow Boiler & Engineering Co.

Controls, Temperature
American Radiator Co.
Consolidated Ashcroft Hancock Co., Inc. (American Schaeffer & Budenberg Div.)
Klipfel Mfg. Co.
Sarco Co., Inc.
Webster Tallmadge & Co., Inc.
Taylor Instrument Cos.

OZONE EQUIPMENT
United States Ozone Co.

PACKING—Asbestos
Jenkins Bros.
Johns-Manville Corp.
New York Blower Co.

Metallic
Johns-Manville Corp.

Rubber
Jenkins Bros.
Johns-Manville Corp.

Catalogue Data of Manufacturers listed can be located by referring to pages 841 to 844

PANELS (*Access*)
Higgin Mfg. Co.

PIPE—Bending
Badger, E. B., & Sons Co.
Crane Co.
Grinnell Co., Inc.

Cast Iron
American Radiator Co.
Crane Co.
Grinnell Co., Inc.
Stockham Pipe & Fittings Co.

Coils (*See Coils, Pipe*)

Covering (*See Covering, Pipe and Tank; also, Conduits*)

Fittings
American District Steam Co.
Crane Co.
Grinnell Co., Inc.
Stockham Pipe & Fittings Co.

Hangers (*See Hangers, Pipe*)

Joint Cement (*See Cement, Pipe Joint*)

Plugs (*See Plugs, Pipe*)

Wrought Iron and Steel
Crane Co.
Grinnell Co., Inc.

PIPELESS FURNACES (*See Furnaces, Pipeless*)

PITOT TUBES AND GAGES
American Blower Corp.
Clarage Fan Co.
Higgin Mfg. Co.
Hill, E. Vernon, Co.

PLATES—Floor
American Radiator Co.
Crane Co.
Grinnell Co., Inc.
National Radiator Corp.
New York Air Valve Corp.
U. S. Radiator Corp.

PLUGS—Fusible
Crane Co.

Pipe
Crane Co.
Grinnell Co., Inc.

POWER PLANT SUPPLIES
American Blower Corp.
American Radiator Co.
Armstrong Machine Works
Buffalo Forge Co.
Clarage Fan Co.
Combustion Specialties Corp.
Consolidated Ashcroft Hancock Co., Inc. (American Schaeffer & Budenberg Div.)
Crane Co.
Davis, G. M., Regulator Co.
Dunham, C. A., Co.
Economy Pumping Machinery Co.
Finn Pump, M. J., Mfg. Co.
General Air Filters Corp.
General Electric Co.
Grinnell Co., Inc.
Illinois Engineering Co.
Jenkins Bros.
Johns-Manville Corp.
Kieley & Mueller, Inc.
Klipfel Mfg. Co.
Mason Regulator Co.
McAlear Mfg. Co.
Mueller Co.
Mueller Steam Specialty Co., Inc.
National Regulator Co.
Sarco Co., Inc.
Stickle Steam Specialties Co.
Sturtevant, B. F., Co.
Swartwout Co., The
Trane Co., The

PRESSURE GAGES (*See Gages Pressure*)

PROTECTORS—Gage Glass
Wright-Austin Co.

Radiator
American Radiator Co.
Reed Air Filter Co.
Tuttle & Bailey Mfg. Co.
U. S. Radiator Corp.

PSYCHROMETERS
Grinnell Co., Inc.
Higgin Mfg. Co.
Hill, E. Vernon, Co.
Taylor Instrument Cos.

PUBLICATIONS
Adsco Advocate
American Society of Heating and Ventilating Engineers
Dunham, C. A., Co.
Heating & Ventilating Magazine
Hill, E. Vernon, Co.
Warren Webster & Co.

PUMPS—Air
American Steam Pump Co.
Ames Pump Co., Inc.
Bishop & Babcock Sales Co., The
Chicago Pump Co.
Economy Pumping Machinery Co.
Finn Pump, M. J., Mfg. Co.
General Electric Co.
McAlear Mfg. Co.
Nash Engineering Co.
O-E Specialty Mfg. Co.
Powers Regulator Co.
Trane Co., The

Ammonia
American Steam Pump Co.
Buffalo Steam Pump Co.
Chicago Pump Co.
Economy Pumping Machinery Co.

Automatic Electric
American Steam Pump Co.
Ames Pump Co., Inc.
Buffalo Steam Pump Co.
Chicago Pump Co.
Economy Pumping Machinery Co.
Finn Pump, M. J., Mfg. Co.
General Air Filters Corp.
Nash Engineering Co.
Skidmore Corp.
Sterling Engineering Co.
Trane Co., The
Westco-Chippewa Pump Co.

Bilge
American Steam Pump Co.
Buffalo Steam Pump Co.
Chicago Pump Co.
Economy Pumping Machinery Co.
Nash Engineering Co.

Boiler Feed
American Steam Pump Co.
Buffalo Steam Pump Co.
Chicago Pump Co.
Economy Pumping Machinery Co.
Finn Pump, M. J., Mfg. Co.
Nash Engineering Co.
Skidmore Corp.
Sterling Engineering Co.
Trane Co., The
Westco-Chippewa Pump Co.

Booster
Chicago Pump Co.

Brine
American Steam Pump Co.
Buffalo Steam Pump Co.
Chicago Pump Co.
Economy Pumping Machinery Co.
Finn Pump, M. J., Mfg. Co.
Nash Engineering Co.
Trane Co., The
Westco-Chippewa Pump Co.

Centrifugal
American Steam Pump Co.
Ames Pump Co., Inc.
Buffalo Steam Pump Co.
Chicago Pump Co.
Dunham, C. A., Co.
Economy Pumping Machinery Co.
Finn Pump, M. J., Mfg. Co.
General Air Filters Corp.
Nash Engineering Co.
Skidmore Corp.
Trane Co., The
Westco-Chippewa Pump Co.

Circulating
American Steam Pump Co.
Ames Pump Co., Inc.
Buffalo Steam Pump Co.
Chicago Pump Co.
Dunham, C. A., Co.
Economy Pumping Machinery Co.
Finn Pump, M. J., Mfg. Co.
General Air Filters Corp.
Nash Engineering Co.
Sterling Engineering Co.
Trane Co., The
Westco-Chippewa Pump Co.

Condensation
American Steam Pump Co.
Ames Pump Co., Inc.
Buffalo Steam Pump Co.
Chicago Pump Co.
Dunham, C. A., Co.
Economy Pumping Machinery Co.
Finn Pump, M. J., Mfg. Co.
General Air Filters Corp.
Nash Engineering Co.
Skidmore Corp.
Sterling Engineering Co.
Trane Co., The
Westco-Chippewa Pump Co.

Catalogue Data of Manufacturers listed can be located by referring to pages 841 to 844

Differential Vacuum
Dunham, C. A., Co.
Economy Pumping Machinery Co.
Finn Pump, M. J., Mfg. Co.

Electric
American Steam Pump Co.
Ames Pump Co., Inc.
Buffalo Steam Pump Co.
Chicago Pump Co.
Dunham, C. A., Co.
Economy Pumping Machinery Co.
Finn Pump, M. J., Mfg. Co.
General Air Filters Corp.
Nash Engineering Co.
Skidmore Corp.
Trane Co., The
Westco-Chippewa Pump Co.

Fire
Chicago Pump Co.

Fittings—Steel
Stockham Pipe & Fittings Co.

Fuel Oil
Ames Pump Co., Inc.
Ballard Oil Equipment Co.
Finn Pump, M. J., Mfg. Co.
General Air Filters Corp.
McCord Radiator & Mfg. Co.
Petroleum Heat & Power Co.

Fuel Oil—Electric
Finn Pump, M. J., Mfg. Co.
Petroleum Heat & Power Co.

High Pressure Steam Fuel Oil
Ballard Oil Equipment Co.
Finn Pump, M. J., Mfg. Co.
Petroleum Heat & Power Co.

House or Tank
Chicago Pump Co.

Portable L. G.
Chicago Pump Co.

Refrigeration
Chicago Pump Co.

Rotary
Buffalo Steam Pump Co.
Economy Pumping Machinery Co.
Finn Pump, M. J., Mfg. Co.
Garden City Fan Co.
General Air Filters Corp.
Leader Iron Works
McCord Radiator & Mfg. Co.
Nash Engineering Co.
Skidmore Corp.
Trane Co., The
Westco-Chippewa Pump Co.

Sewage
Chicago Pump Co.

Steam
American Steam Pump Co.
Buffalo Steam Pump Co.
Economy Pumping Machinery Co.
Finn Pump, M. J., Mfg. Co.
Nash Engineering Co.

Sump
American Steam Pump Co.
Buffalo Steam Pump Co.
Chicago Pump Co.
Economy Pumping Machinery Co.
Finn Pump, M. J., Mfg. Co.
Nash Engineering Co.
Trane Co., The

Triplex
Buffalo Steam Pump Co.
Finn Pump, M. J., Mfg. Co.

Turbine
American Steam Pump Co.
Ames Pump Co., Inc.
Buffalo Steam Pump Co.
Economy Pumping Machinery Co.
Finn Pump, M. J., Mfg. Co.
General Air Filters Corp.
Nash Engineering Co.
Skidmore Corp.
Trane Co., The
Westco-Chippewa Pump Co.

Vacuum
American Steam Pump Co.
Ames Pump Co., Inc.
Buffalo Steam Pump Co.
Chicago Pump Co.
Dunham, C. A., Co.
Economy Pumping Machinery Co.
Finn Pump, M. J., Mfg. Co.
Kieley & Mueller, Inc.
McAlear Mfg. Co.
Nash Engineering Co.
O-E Specialty Mfg. Co.
Skidmore Corp.
Trane Co., The

Viscous Liquids
General Air Filters Corp.

Water Supply
Chicago Pump Co.

RADIATOR—Air Valves (*See Valves, Air*)

Brackets
American Foundry & Furnace Co.
American Radiator Co.
Burnham Boiler Corp.
Clip-Bar Mfg. Co.
Grinnell Co., Inc.
Healy-Ruff Co.
Hoffman Specialty Co., Inc.
Kewanee Boiler Corp.
Little Giant Mfg. Co., The
McAlear Mfg. Co., The
National Radiator Corp.
Pierce, Butler & Pierce Mfg. Corp.
Smith, H. B., Co., The
Thatcher Co., The
U. S. Radiator Corp.

Covers
American Radiator Co.
Reed Air Filter Co.
Tuttle & Bailey Mfg. Co.
U. S. Radiator Corp.

Elbows (*See Elbows, Radiator*)

Electric—Steam
American Radiator Co.
Rome Brass Radiator Corp.
Trane Co., The

Enclosures
American Radiator Co.
Auer Register Co.
Buckeye Blower Co., The
Circulair Heat, Inc.
Copper Radiator Sales Corp.
Herman Nelson Corp.
Reed Air Filter Co.
Rome Brass Radiator Corp.
Sturtevant, B. F., Co.
Trane Co., The
Tuttle & Bailey Mfg. Co.

Hangers (*See Hangers, Radiator*)

Humidifiers (*See Humidifiers*)

Return Line Valves (*See Valves, Return Line*)

Shields (*See Protectors, Radiator*)

Traps (*See Traps, Radiator*)

Trucks (*See Trucks, Radiator*)

Valves (*See Valves, Radiator*)

RADIATORS—Concealed
Circulair Heat, Inc.
Copper Radiator Sales Corp.
McQuay Radiator Corp.
Herman Nelson Corp.
Rome Brass Radiator Corp.
Trane Co., The

Copper
Copper Radiator Sales Corp.

Fan System
Aerofin Corp.
American Blower Corp.
American Radiator Co.
Buckeye Blower Co., The
Buffalo Forge Co.
Burnham Boiler Corp.
Circulair Heat, Inc.
Clarage Fan Co.
Herman Nelson Corp.
Niagara Blower Co.
Rome Brass Radiator Corp.
Rome-Turney Radiator Co., The
Schutte & Koerting Co.
Smith, H. B., Co., The
Sturtevant, B. F., Co.
Trane Co., The
York Heating & Ventilating Corp.

Electric
American Radiator Co.

Gas
American Gas Products Corp.

Hot Water
Aerofin Corp.
American Blower Corp.
American Radiator Co.
Bayley Blower Co.
Buckeye Blower Co., The
Burnham Boiler Corp.
Circulair Heat, Inc.
Clarage Fan Co.
Ilg Electric Ventilating Co.

Catalogue Data of Manufacturers listed can be located by referring to pages 841 to 844

Johnson Fan & Blower Co.
Kewanee Boiler Corp.
National Radiator Corp.
Herman Nelson Corp.
Niagara Blower Co.
Page, Wm. H., Boiler Co.
Pierce, Butler & Pierce Mfg. Corp.
Reed Air Filter Co.
Richmond Radiator Co.
Rome Brass Radiator Corp.
Rome-Turney Radiator Co., The
Schutte & Koerting Co.
Smith, H. B., Co., The
Sturtevant, B. F., Co.
Thatcher Co., The
Trane Co., The
U. S. Radiator Corp.
Weil-McLain Co.
York Heating & Ventilating Corp.

Steam
Aerofin Corp.
American Blower Corp.
American Gas Products Corp.
American Radiator Co.
Bayley Blower Co.
Buckeye Blower Co., The
Buffalo Forge Co.
Burnham Boiler Corp.
Circulair Heat, Inc.
Clarage Fan Co.
Kewanee Boiler Corp.
National Radiator Corp.
Herman Nelson Corp.
Niagara Blower Co.
Page, Wm. H., Boiler Co.
Pierce, Butler & Pierce Mfg. Corp.
Reed Air Filter Co.
Richmond Radiator Co.
Rome Brass Radiator Corp.
Rome-Turney Radiator Co., The
Schutte & Koerting Co.
Smith, H. B., Co., The
Sturtevant, B. F., Co.
Thatcher Co., The
Trane Co., The
U. S. Radiator Corp.
Weil-McLain Co.
York Heating & Ventilating Corp.

Wall
American Radiator Co.
Buckeye Blower Co., The
Burnham Boiler Corp.
Circulair Heat, Inc.
Clarage Fan Co.
Kewanee Boiler Corp.
National Radiator Corp.
Page, Wm. H., Boiler Co.
Pierce, Butler & Pierce Mfg. Corp.
Reed Air Filter Co.
Richmond Radiator Co.
Rome Brass Radiator Corp.
Smith, H. B., Co., The
Thatcher Co., The
Trane Co., The
U. S. Radiator Corp.
Weil-McLain Co.

RECEIVERS—Air
Economy Pumping Machinery Co.
Finn Pump, M. J., Mfg. Co.
Frost Mfg. Co., The
General Air Filters Corp.
Illinois Engineering Co.
Kewanee Boiler Corp.
Kieley & Mueller, Inc.
Klipfel Mfg. Co.
Leader Iron Works
McAlear Mfg. Co., The
Titusville Iron Works Co., The
Trane Co., The
Whitlock Coil Pipe Co.

Ammonia
Crane Co.
General Air Filters Corp.
Leader Iron Works
Titusville Iron Works Co., The
Whitlock Coil Pipe Co.

Condensation
American District Steam Co.
American Gas Products Corp.
Bishop & Babcock Sales Co., The
Buffalo Steam Pump Co.
Chicago Pump Co.
Crane Co.
Davis, G. M., Regulator Co.
Economy Pumping Machinery Co.
Finn Pump, M. J., Mfg. Co.
General Air Filters Corp.
Illinois Engineering Co.
Kieley & Mueller, Inc.
Klipfel Mfg. Co.
Leader Iron Works
Mason Regulator Co.
McAlear Mfg. Co.
Mueller Steam Specialty Co., Inc.
Nash Engineering Co.
Sterling Engineering Co.
Titusville Iron Works Co., The
Trane Co., The

REFRIGERATING MACHINERY
Carrier Engineering Corp.
Finn Pump, M. J., Mfg. Co.

REFRIGERATING SECTIONS
American Radiator Co.
McCord Radiator & Mfg. Co.
Rome Brass Radiator Corp.

REFRIGERATOR INSULATION
Armstrong Cork Insulation Co.
Celotex Co.
Flaxlinum Insulating Co.
MacAndrews & Forbes Co.
Pantasote Co., Inc.
Stewart Inso Board Co.

REGISTERS—Warm Air
Auer Register Co.

REGISTERS AND GRILLES
Auer Register Co.
Knowles Mushroom Ventilator Co.
Sturtevant, B. F., Co.
Tuttle & Bailey Mfg. Co.

REGISTERS AND GRILLES—Ventilating
Auer Register Co.
Buckeye Blower Co., The
Tuttle & Bailey Mfg. Co.

REGULATORS—Damper
Absolute Con-tac-tor Corp.
American District Steam Co.
American Radiator Co.
Bishop & Babcock Sales Co., The
Burnham Boiler Corp.
Carrier Engineering Corp.
Consolidated Ashcroft Hancock Co., Inc. (American Schaeffer & Budenberg Div.)
Cooling & Air Conditioning Corp.
D. & T. Mfg. Co.
Dunham, C. A., Co.
General Electric Co.
Haines, William S., & Co.
Hoffman Specialty Co., Inc.
Illinois Engineering Co.
Jenkins Bros.
Kainer & Co.
Kieley & Mueller, Inc.
Klipfel Mfg. Co.
Marine-Galligan Co., Inc.
Marsh, Jas. P., & Co.
Mason Regulator Co.
McAlear Mfg. Co.
Mueller Co.
National Radiator Corp.
National Regulator Co.
Powers Regulator Co.
Sarco Co., Inc.
Shipp, C. C., & Co.
Sterling Engineering Co.
Stickle Steam Specialties Co.
Swartwout Co., The
Thrush, H. A., & Co.
Trane Co., The
U. S. Radiator Corp.
Vapor Engineering Co., Inc.
Warren Webster & Co.
Wing, L. J., Mfg. Co.

Feed Water
American Radiator Co.
Consolidated Ashcroft Hancock Co., Inc. (American Schaeffer & Budenberg Div.)
Davis, G. M., Regulator Co.
Finn Pump, M. J., Mfg. Co.
Kieley & Mueller, Inc.
Klipfel Mfg. Co.
Mason Regulator Co.
McAlear Mfg. Co.
McDonnell & Miller
Mueller Steam Specialty Co., Inc.
Sarco Co., Inc.
Stickle Steam Specialties Co.
Swartwout Co., The
Taylor Instrument Cos.
U. S. Radiator Corp.
Wright-Austin Co.

Humidity
Carrier Engineering Corp.
Consolidated Ashcroft Hancock Co., Inc. (American Schaeffer & Budenberg Div.)
Cooling and Air Conditioning Corp.
Grinnell Co., Inc.
Johnson Service Co.
Klipfel Mfg. Co.
National Regulator Co.
Powers Regulator Co.
Taylor Instrument Cos.

Pressure
Absolute Con-tac-tor Corp.
American Radiator Co.
Bishop & Babcock Sales Co., The
Consolidated Ashcroft Hancock Co., Inc. (American Schaeffer & Budenberg Div.)
Crane Co.
Davis, G. M., Regulator Co.
Dunham, C. A., Co.
Finn Pump, M. J., Mfg. Co.
General Electric Co.

Catalogue Data of Manufacturers listed can be located by referring to pages 841 to 844

Hoffman Specialty Co., Inc.
Illinois Engineering Co.
Jenkins Bros.
Johnson Service Co.
Kainer & Co.
Kieley & Mueller, Inc.
Klipfel Mfg. Co.
Mason Regulator Co.
McAlear Mfg. Co.
McDonnell & Miller
Mueller Co.
Mueller Steam Specialty Co., Inc.
National Regulator Co.
O-E Specialty Mfg. Co.
Petroleum Heat & Power Co.
Powers Regulator Co.
Stickle Steam Specialties Co.
Swartwout Co., The
Webster Tallmadge & Co., Inc.
Taylor Instrument Cos.
Thrush, H. A., & Co.
Trane Co., The
U. S. Radiator Corp.
Vapor Engineering Co., Inc.

Pump

American Radiator Co.
Bishop & Babcock Sales Co., The
Consolidated Ashcroft Hancock Co., Inc. (American Schaeffer & Budenberg Div.)
Davis, G. M., Regulator Co.
Dunham, C. A., Co.
Economy Pumping Machinery Co.
Finn Pump, M. J., Mfg. Co.
Illinois Engineering Co.
Kieley & Mueller, Inc.
Klipfel Mfg. Co.
Mason Regulator Co.
McAlear Mfg. Co.
Mueller Co.
Mueller Steam Specialty Co., Inc.
Stickle Steam Specialties Co.
Swartwout Co., The
Trane Co., The
Wright-Austin Co.

Steam

Absolute Con-tac-tor Corp.
American District Steam Co.
American Radiator Co.
Bishop & Babcock Sales Co., The
Consolidated Ashcroft Hancock Co., Inc. (American Schaeffer & Budenberg Div.)
Davis, G. M., Regulator Co.
Direct Control Valve Co.
Dunham, C. A., Co.
Illinois Engineering Co.
Jenkins Bros.
Kieley & Mueller, Inc.
Klipfel Mfg. Co.
Mason Regulator Co.
McAlear Mfg. Co.
McDonnell & Miller
Mueller Co.
Mueller Steam Specialty Co., Inc.
National Regulator Co.
Petroleum Heat & Power Co.
Powers Regulator Co.
Sarco Co., Inc.
Stickle Steam Specialties Co.
Swartwout Co., The
Webster Tallmadge & Co., Inc.
Trane Co., The
U. S. Radiator Corp.
Warren Webster & Co.
Wing, L. J., Mfg. Co.

Temperature

Absolute Con-tac-tor Corp.
American Radiator Co.
Bishop & Babcock Sales Co., The
Burnham Boiler Corp.
Carrier Engineering Corp.
Consolidated Ashcroft Hancock Co., Inc. (American Schaeffer & Budenberg Div.)
Cooling and Air Conditioning Corp.
D. & T. Mfg. Co.
Direct Control Valve Co.
General Electric Co.
Illinois Engineering Co.
Johnson Service Co.
Kieley & Mueller, Inc.
Klipfel Mfg. Co.
National Radiator Corp.
National Regulator Co.
O-E Specialty Mfg. Co.
Powers Regulator Co.
Sarco Co., Inc.
Sterling Engineering Co.
Webster Tallmadge & Co., Inc.
Taylor Instrument Cos.
Thrush, H. A., & Co.
U. S. Radiator Corp.

Vacuum

Absolute Con-tac-tor Corp.
American Radiator Co.
Bishop & Babcock Sales Co., The
Chicago Pump Co.
Consolidated Ashcroft Hancock Co., Inc. (American Schaeffer & Budenberg Div.)
Davis, G. M., Regulator Co.
Direct Control Valve Co.
Dunham, C. A., Co.
Economy Pumping Machinery Co.
Finn Pump, M. J., Mfg. Co.
Haines, William S., & Co.
Hoffman Specialty Co., Inc.
Illinois Engineering Co.
Jenkins Bros.
Kieley & Mueller, Inc.
Klipfel Mfg. Co.
Marine-Galligan Co., Inc.
Mason Regulator Co.
McAlear Mfg. Co.
Mueller Co.
Mueller Steam Specialty Co., Inc.
National Radiator Corp.
National Regulator Co.
O-E Specialty Mfg. Co.
Stickle Steam Specialties Co.
Taylor Instrument Cos.
Trane Co., The
U. S. Radiator Corp.
Warren Webster & Co.

Vapor

Absolute Con-tac-tor Corp.
American District Steam Co.
American Radiator Co.
Bishop & Babcock Sales Co., The
Burnham Boiler Corp.
Consolidated Ashcroft Hancock Co., Inc. (American Schaeffer & Budenberg Div.)
Davis, G. M., Regulator Co.
Direct Control Valve Co.
Dunham, C. A., Co.
Finn Pump, M. J., Mfg. Co.
Haines, William S., & Co.
Hoffman Specialty Co., Inc.
Illinois Engineering Co.
Jenkins Bros.
Kieley & Mueller, Inc.
Klipfel Mfg. Co.
Marine-Galligan Co., Inc.
Mason Regulator Co.
McAlear Mfg. Co.
Mueller Co.
McDonnell & Miller
Mueller Steam Specialty Co., Inc.
National Regulator Co.
O-E Specialty Mfg. Co.
Powers Regulator Co.
Webster Tallmadge & Co., Inc.
Trane Co., The
U. S. Radiator Corp.
Vapor Engineering Co., Inc.

Water

Absolute Con-tac-tor Corp.
American Radiator Co.
Bishop & Babcock Sales Co., The
Consolidated Ashcroft Hancock Co., Inc. (American Schaeffer & Budenberg Div.)
Davis, G. M., Regulator Co.
Economy Pumping Machinery Co.
Finn Pump, M. J., Mfg. Co.
Jenkins Bros.
Kieley & Mueller, Inc.
Klipfel Mfg. Co.
Mason Regulator Co.
McAlear Mfg. Co.
Mueller Co.
Mueller Steam Specialty Co., Inc.
National Regulator Co.
Powers Regulator Co.
Sarco Co., Inc.
Swartwout Co., The
U. S. Radiator Corp.

Water Level (*See Controllers*)

REHEATERS—Air

Aerofin Corp.
American Blower Corp.
American Radiator Co.
Bayley Blower Co.
Buckeye Blower Co., The
Buffalo Forge Co.
General Air Filters Corp.
Ilg Electric Ventilating Co.
New York Blower Co.
Niagara Blower Co.
Rome Brass Radiator Corp.
Schutte & Koerting Co.
Stickle Steam Specialties Co.
Sturtevant, B. F., Co.
York Heating & Ventilating Corp.

RELAY SWITCHES (*See Switches, Control and Relay*)

ROOF INSULATION

Samuel Cabot, Inc.
Celotex Co.
Johns-Manville Corp.
MacAndrews & Forbes Co.
Masonite Corp.
Pantasote Co., Inc.
Sprayo-Flake Co.
Stewart Inso Board Co.
Wood Conversion Co.

ROOF VENTILATORS (*See Ventilators, Roof*)

ROTARY DRYERS (*See Drying Apparatus*)

ROTARY HACK SAW TOOLS

American Radiator Co.
Excelso Products Corp.
Mueller Steam Specialty Co., Inc

Catalogue Data of Manufacturers listed can be located by referring to pages 841 to 844

SCALE REMOVER—Boiler

O-E Specialty Mfg. Co.
Vinco Co., Inc., The

SCRUBBERS, AIR

American Blower Corp.
Bayley Blower Co.
Bentz Engineering Corp.
Buffalo Forge Co.
Niagara Blower Co.
Sturtevant, B. F., Co.

SEPARATORS—Dust

American Blower Corp.
Bayley Blower Co.
Buffalo Forge Co.
Clarage Fan Co.
New York Blower Co.
Niagara Blower Co.
Sturtevant, B. F., Co.

Steam and Oil

American District Steam Co.
Bishop & Babcock Sales Co., The
Crane Co.
Davis Engineering Corp.
Illinois Engineering Co.
Kieley & Mueller, Inc.
McAlear Mfg. Co.
Patterson-Kelley Co.
Stickle Steam Specialties Co.
Swartwout Co., The
Warren Webster & Co.
Wright-Austin Co.

SHEETS—Asbestos

Johns-Manville Corp.
New York Blower Co.

SHIELDS (*See Protectors, Radiator*)

SHOWER BATH CONTROLLERS (*See Controllers, Shower Bath*)

Sound Deadening (*See Insulation*)

SIPHONS—Gage

Little Giant Mfg. Co., The

SMOKE CONSUMER

Bayley Blower Co.
Combustion Specialties Corp.

SOFTENERS, WATER (*See Water Softeners*)

SPECIALTIES, HEATING (*See Heating Specialties*)

SPECIALTIES—Sheet Metal

American Foundry & Furnace Co.
Sturtevant, B. F., Co.
York Heating & Ventilating Corp.

SPECIALTIES, STEAM (*See Steam Specialties*)

SPRAY COOLING SYSTEMS

American Blower Corp.
Atmospheric Conditioning Corp.
Bayley Blower Co.
Buffalo Forge Co.
Carrier Engineering Corp.
Clarage Fan Co.
Cooling and Air Conditioning Corp.
Finn Pump, M. J., Mfg. Co.
General Air Filters Corp.
New York Blower Co.
Niagara Blower Co.
Sturtevant, B. F., Co.

SPRAY NOZZLES (*See Nozzles, Spray*)

STACKS—Steel

Bigelow Co., The

STEAM CALORIMETERS (*See Calorimeters, Steam*)

STEAM ENGINES (*See Engines, Steam*)

STEAM HEATING SYSTEMS (*See Heating Systems, Steam*)

STEAM AND WATER MIXERS (*Thermostatic*) (*See Mixers*)

STEAM SPECIALTIES

Absolute Con-tac-tor Corp.
American District Steam Co.
American Radiator Co.
Armstrong Machine Works
Barnes & Jones
Bell & Gossett Co.
Bishop & Babcock Sales Co., The
Consolidated Ashcroft Hancock Co., Inc. (American Schaeffer & Budenberg Div.)
Crane Co.
Davis, G. M., Regulator Co.
Direct Control Valve Co.
Dunham, C. A., Co.
General Air Filters Corp.
Haines, William S., & Co.
Hoffman Specialty Co.
Illinois Engineering Co.
Johns-Manville Corp.
Kelly Brass Works
Kieley & Mueller, Inc.
Klipfel Mfg. Co.
Marine-Galligan Co., Inc.
Marsh, Jas. P., & Co.
Mason Regulator Co.
McAlear Mfg. Co.
Mueller Co.
Mueller Steam Specialty Co., Inc.
National Regulator Co.
O-E Specialty Mfg. Co.
Powers Regulator Co.
Russell, W. A., & Co.
Sarco Co., Inc.
Sterling Engineering Co.
Stickle Steam Specialties Co.
Swartwout Co., The
Webster Tallmadge & Co., Inc.
Trane Co., The
U. S. Radiator Corp.
Warren Webster & Co.
Wright-Austin Co.

STOKERS—Automatic

Whiting Corp. (Harrington Stoker Div.)

Mechanical

Whiting Corp. (Harrington Stoker Div.)

STRAINERS—Oil

Absolute Con-tac-tor Corp.
Consolidated Ashcroft Hancock Co., Inc. (American Schaeffer & Budenberg Div.)
Crane Co.
Davis, G. M., Regulator Co.
Illinois Engineering Co.
Kieley & Mueller, Inc.
Mason Regulator Co.
McAlear Mfg. Co.
Mueller Co.
Mueller Steam Specialty Co., Inc.
Petroleum Heat & Power Co.
Sarco Co., Inc.
Trane Co., The
Wright-Austin Co.

Steam

Bishop & Babcock Sales Co., The
Consolidated Ashcroft Hancock Co., Inc. (American Schaeffer & Budenberg Div.)
Crane Co.
Davis, G. M., Regulator Co.
Dunham, C. A., Co.
Illinois Engineering Co.
Kieley & Mueller, Inc.
Mason Regulator Co.
McAlear Mfg. Co.
Mueller Co.
Mueller Steam Specialty Co., Inc.
Sarco Co., Inc.
Sterling Engineering Co.
Swartwout Co., The
Wright-Austin Co.

Water

American District Steam Co.
Bell & Gossett Co.
Crane Co.
Davis, G. M., Regulator Co.
Dunham, C. A., Co.
Finn Pump, M. J., Mfg. Co.
Illinois Engineering Co.
Kieley & Mueller, Inc.
Mason Regulator Co.
McAlear Mfg. Co.
Mueller Co.
Mueller Steam Specialty Co., Inc.
Sarco Co., Inc.
Sterling Engineering Co.
Swartwout Co., The
Wright-Austin Co.

STRUCTURAL INSULATION

Armstrong Cork & Insulation Co.
Samuel Cabot, Inc.
Celotex Co.
Flax-li-num Insulating Co.
Insulating Products Corp.
Johns-Manville Corp.
MacAndrews & Forbes Co.
Masonite Corp.
Pantasote Co., Inc.
Stewart Inso Board Co.
United States Gypsum Co.
Universal Gypsum & Lime Co.
Wood Conversion Co.

SUPPLIES—Power Plant (*See Power Plant Supplies*)

SUPPORTS (*See Hangers, Pipe and Radiator*)

SWITCHES—Control-Relay

Absolute Con-tac-tor Corp.
American Radiator Co.
General Electric Co.
McAlear Mfg. Co., The
McDonnell & Miller
National Regulator Co.
Powers Regulator Co.
Trane Co., The

Catalogue Data of Manufacturers listed can be located by referring to pages 841 to 844

Thermostatic-Relay
American Radiator Co.

Safety
General Electric Co.

SYSTEMS—Domestic Hot Water
Absolute Con-tac-tor Corp.
American Gas Products Corp.
American Radiator Co.
Bell & Gossett Co.
Burnham Boiler Corp.
Davis Engineering Corp.
Excelso Products Corp.
Finn Pump, M. J., Mfg. Co.
Kainer & Co.
Mueller Co.
Richardson & Boynton Co.
Rome Brass Radiator Corp.
Smith, H. B., Co., The
Spencer Heater Co.
Thrush, H. A., & Co.
U. S. Radiator Corp.

Dust Collecting
American Blower Corp.
Bayley Blower Co.
Buckeye Blower Co., The
Buffalo Forge Co.
Carrier Engineering Corp.
Clarage Fan Co.
Garden City Fan Co.
General Air Filters Corp.
Midwest Air Filters, Inc.
National Air Filter Co.
New York Blower Co.
Niagara Blower Co.
Reed Air Filter Co.
Skinner Bros. Mfg. Co., Inc.
Sturtevant, B. F., Co.
Whiting Corp.

Exhaust (*See Exhaust Systems*)

Hot Blast
Aerofin Corp.
American Blower Corp.
American Radiator Co.
Bayley Blower Co.
Buckeye Blower Co., The
Buffalo Forge Co.
Carrier Engineering Corp.
Clarage Fan Co.
Garden City Fan Co.
Ilg Electric Ventilating Co.
Langenberg Mfg. Co.
New York Blower Co.
O-E Specialty Mfg. Co.
Rome Brass Radiator Corp.
Schutte & Koerting Co.
Skinner Bros. Mfg. Co., Inc.
Stickle Steam Specialties Co.
Sturtevant, B. F., Co.
Trane Co., The
Wing, L. J., Mfg. Co.
York Heating & Ventilating Corp.

Spray Cooling (*See Spray Cooling Systems*)

Temperature Control
Absolute Con-tac-tor Corp.
American Blower Corp.
American Radiator Co.
Bentz Engineering Corp.
Bishop & Babcock Sales Co., The
Buffalo Forge Co.
Carrier Engineering Corp.
Clarage Fan Co.
Consolidated Ashcroft Hancock Co., Inc. (American Schaeffer & Budenberg Div.)
Cooling & Air Conditioning Corp.
Direct Control Valve Co.
General Electric Co.
Illinois Engineering Co.
Johnson Service Co.
Kainer & Co.
Kieley & Mueller, Inc.
Klipfel Mfg. Co.
Mueller Co.
National Regulator Co.
Niagara Blower Co.
Powers Regulator Co.
Sarco Co., Inc.
Sterling Engineering Co.
Sturtevant, B. F., Co.
Webster Tallmadge & Co., Inc.
Taylor Instrument Cos.
Trane Co., The

Ventilating (*See Ventilating Systems*)

Water
Crane Co.
Chicago Pump Co.
Economy Pumping Machinery Co.
Finn Pump, M. J., Mfg. Co.
Leader Iron Works
Trane Co., The
Westco-Chippewa Pump Co.

TANK—Coils (*See Coils, Tank*)

Covering (*See Covering, Pipe and Tank*)

Heaters (*See Heaters, Tank*)

Regulators
Absolute Con-tac-tor Corp.
American Radiator Co.
Bishop & Babcock Sales Co., The
Consolidated Ashcroft Hancock Co., Inc. (American Schaeffer & Budenberg Div.)
Davis, G. M., Regulator Co.
Direct Control Valve Co.
Johnson Service Co.
Kainer & Co.
Kieley & Mueller, Inc.
Klipfel Mfg. Co.
Mason Regulator Co.
McAlear Mfg. Co.
Mueller Co.
Mueller Steam Specialty Co., Inc.
National Regulator Co.
Page, Wm. H., Boiler Co.
Powers Regulator Co.
Sarco Co., Inc.
Stickle Steam Specialties Co.
Swartwout Co., The
Thrush, H. A., & Co.
Trane Co., The

TANKS—Blow-Off
Bigelow Co., The
Coatesville Boiler Works
Economy Pumping Machinery Co.
General Air Filters Corp.
Herbert Boiler Co.
Kewanee Boiler Corp.
Leader Iron Works
Oil City Boiler Works
Stanwood Corp., The
Titusville Iron Works Co., The

Cast Iron
Bishop & Babcock Sales Co., The
Davis Engineering Corp.
D. & T. Mfg. Co.
Economy Pumping Machinery Co.
Excelso Products Corp.
Frank, O. E., Heater & Engineering Co., Inc.
Mueller Co.
Neptune Meter Co.
Patterson-Kelley Co.
Thrush, H. A., & Co.
Whitlock Coil Pipe Co.

Hot Water
Coatesville Boiler Works
Davis Engineering Corp.
Finn Pump, M. J., Mfg. Co.
Leader Iron Works
Titusville Iron Works Co., The

Pressure
Ames Iron Works
Bigelow Co., The
Burnham Boiler Corp.
Coatesville Boiler Works
Consolidated Ashcroft Hancock Co., Inc. (American Schaeffer & Budenberg Div.)
Edge Moor Iron Co.
General Air Filters Corp.
Harrisburg Star Boiler Corp.
Herbert Boiler Co.
Kainer & Co.
Kewanee Boiler Corp.
Kieley & Mueller, Inc.
Leader Iron Works
Mueller Co.
Oil City Boiler Works
Stanwood Corp., The
Thrush, H. A., & Co.
Titusville Iron Works Co., The

Steam
Coatesville Boiler Works
Leader Iron Works
Titusville Iron Works Co., The

Storage
American Radiator Co.
Ames Iron Works
Bigelow Co., The
Burnham Boiler Corp.
Coatesville Boiler Works
Davis Engineering Co.
Edge Moor Iron Co.
Frank, O. E., Heater & Engineering Co.
General Air Filters Corp.
Harrisburg Star Boiler Corp.
Herbert Boiler Co.
Kewanee Boiler Corp.
Leader Iron Works
National Radiator Corp.
Oil City Boiler Works
Page, Wm. H., Boiler Co.
Patterson-Kelley Co.
Stanwood Corp., The
Titusville Iron Works Co., The

TEMPERATURE REGULATORS (*See Regulators, Temperature*)

THERMOMETERS
American Radiator Co.
Bishop & Babcock Sales Co., The
Burnham Boiler Corp.

Catalogue Data of Manufacturers listed can be located by referring to pages 841 to 844

Consolidated Ashcroft Hancock Co., Inc. (American Schaeffer & Budenberg Div.)
Hill, E. Vernon, Co.
Marsh, Jas. P., & Co.
National Radiator Corp.
Pierce, Butler & Pierce Mfg. Corp.
Powers Regulator Co.
Taylor Instrument Cos.
Thrush, H. A., & Co.
U. S. Radiator Corp.

THERMOSTATS
Absolute Con-tac-tor Corp.
American Radiator Co.
Bishop & Babcock Sales Co., The
Burnham Boiler Corp.
Consolidated Ashcroft Hancock Co., Inc. (American Schaeffer & Budenberg Div.)
General Electric Co.
Johnson Service Co.
Kieley & Mueller, Inc.
Klipfel Mfg. Co.
National Regulator Co.
Powers Regulator Co.
Sarco Co., Inc.
Taylor Instrument Cos.
U. S. Radiator Corp.

TRAPS—Air
Grinnell Co., The

Air Blast
Armstrong Machine Works
Barnes & Jones
Davis, G. M., Regulator Co.
Haines, William S., & Co.

Differential Vacuum
Dunham, C. A., Co.

Float
American District Steam Co.
Armstrong Machine Works
Barnes & Jones
Crane Co.
Davis Engineering Corp.
Davis, G. M., Regulator Co.
Dunham, C. A., Co.
General Air Filters Corp.
Haines, William S., & Co.
Hoffman Specialty Co., Inc.
Illinois Engineering Co.
Kieley & Mueller, Inc.
Klipfel Mfg. Co.
Marine-Galligan Co., Inc.
McAlear Mfg. Co., The
Mueller Steam Specialty Co., Inc.
Sarco Co., Inc.
Sterling Engineering Co.
Stickle Steam Specialties Co.
Swartwout Co., The
Trane Co., The

Float and Thermostatic
Dunham, C. A., Co.

Radiator
American District Steam Co.
Armstrong Machine Works
Barnes & Jones
Bishop & Babcock Sales Co., The
Dunham, C. A., Co.
Haines, William S., & Co.
Hoffman Specialty Co., Inc.
Illinois Engineering Co.
Jenkins Bros.
Johns-Manville Corp.
Marine-Galligan Co., Inc.
Marsh, Jas. P., & Co.
McAlear Mfg. Co.
Monash-Younker Co., Inc.
Mueller Co.
National Radiator Corp.
O-E Specialty Mfg. Co.
Sarco Co., Inc.
Sterling Engineering Co.
Stickle Steam Specialties Co.
Trane Co., The
U. S. Radiator Corp.
Vapor Engineering Co., Inc.
Warren Webster & Co.

Return
American Blower Corp.
American District Steam Co.
Barnes & Jones
Bishop & Babcock Sales Co., The
Crane Co.
Dunham, C. A., Co.
General Air Filters Corp.
Haines, William S., & Co.
Hoffman Specialty Co., Inc.
Illinois Engineering Co.
Jenkins Bros.
Johns-Manville Corp.
Kieley & Mueller, Inc.
Marine-Galligan Co., Inc.
Marsh, Jas. P. & Co.
McAlear Mfg. Co.
Milwaukee Valve Co.
Monash-Younker Co., Inc.
Mueller Steam Specialty Co., Inc.
O-E Specialty Mfg. Co.
Sarco Co., Inc.
Sterling Engineering Co.
Stickle Steam Specialties Co.
Swartwout Co., The
Trane Co., The
U. S. Radiator Corp.
Vapor Engineering Co., Inc.
Warren Webster & Co.

Return (*Siphon*)
Bishop & Babcock Sales Co., The
Marsh, Jas. P., & Co.

Steam
American Blower Corp.
American District Steam Co.
Armstrong Machine Works
Barnes & Jones
Bishop & Babcock Sales Co., The
Consolidated Ashcroft Hancock Co., Inc. (American Schaeffer & Budenberg Div.)
Crane Co.
Davis Engineering Corp.
Davis, G. M., Regulator Co.
Dunham, C. A., Co.
General Air Filters Corp.
Grinnell Co., Inc.
Haines, William S., & Co.
Hoffman Specialty Co., Inc.
Illinois Engineering Co.
Jenkins Bros.
Johns-Manville Corp.
Kieley & Mueller, Inc.
Klipfel Mfg. Co.
Marine-Galligan Co., Inc.
Marsh, Jas. P., & Co.
McAlear Mfg. Co.
Milwaukee Valve Co.
Monash-Younker Co., Inc.
Mueller Steam Specialty Co., Inc.
O-E Specialty Mfg. Co.
Patterson-Kelley Co.
Powers Regulator Co.
Sarco Co., Inc.
Sterling Engineering Co.
Stickle Steam Specialties Co.
Sturtevant, B. F., Co.
Swartwout Co., The
Trane Co., The
U. S. Radiator Corp.
Warren Webster & Co.
Wright-Austin Co.

Thermostatic
American District Steam Co.
Armstrong Machine Works
Barnes & Jones
Dunham, C. A., Co.
Haines, William S., & Co.
Hoffman Specialty Co., Inc.
Jenkins Bros.
McAlear Mfg. Co., The
Milwaukee Valve Co.
Sarco Co., Inc.
Sterling Engineering Co.
Stickle Steam Specialties Co.
Trane Co., The
Vapor Engineering Co., Inc.

Vacuum
American District Steam Co.
Armstrong Machine Works
Barnes & Jones
Bishop & Babcock Sales Co., The
Crane Co.
Dunham, C. A., Co.
Finn Pump, M. J., Mfg. Co.
Haines, William S., & Co.
Hoffman Specialty Co., Inc.
Illinois Engineering Co.
Johns-Manville Corp.
Kieley & Mueller, Inc.
Klipfel Mfg. Co.
Marine-Galligan Co., Inc.
Marsh, Jas. P., & Co.
McAlear Mfg. Co.
Milwaukee Valve Co.
Monash-Younker Co., Inc.
Mueller Steam Specialty Co., Inc.
O-E Specialty Mfg. Co.
Sarco Co., Inc.
Sterling Engineering Co.
Stickle Steam Specialties Co.
Swartwout Co., The
Trane Co., The
U. S. Radiator Corp.
Warren Webster & Co.

TRUCKS—Radiator
Little Giant Mfg. Co., The

TURBINES—Steam
Finn Pump, M. J., Mfg. Co.
General Electric Co.
Sturtevant, B. F., Co.
Wing, L. J., Mfg. Co.

TURBO-BLOWERS
American Blower Corp.
Buffalo Forge Co.
General Electric Co.
New York Blower Co.
Sturtevant, B. F., Co.
Wing, L. J., Mfg. Co.

UNDERGROUND PIPE CONDUIT (*See Conduits, Underground Pipe*)

UNIT HEATERS—(*See Heaters, Unit*)

VACUUM—Cleaning Apparatus
Buffalo Forge Co.
Nash Engineering Co.
Sturtevant, B. F., Co.

Catalogue Data of Manufacturers listed can be located by referring to pages 841 to 844

Dryers (*See Drying Apparatus*)

Gages (*See Gages, Vacuum*)

Heating Systems (*See Heating Systems, Steam Vacuum*).

Pumps (*See Pumps, Vacuum*)

Regulators (*See Regulators, Vacuum*)

Specialties (*See Heating Specialties*)

Traps (*See Traps, Vacuum*)

VALVES—Air

American District Steam Co.
American Foundry & Furnace Co.
American Radiator Co.
Bishop & Babcock Sales Co., The
Burnham Boiler Corp.
Consolidated Ashcroft Hancock Co., Inc. (American Schaeffer & Budenberg Div.)
Crane Co.
Davis, G. M., Regulator Co.
Direct Control Valve Co.
Dole Valve Co., The
Dunham, C. A., Co.
Healy-Ruff Co.
Hoffman Specialty Co., Inc.
Jenkins Bros.
Kelly Brass Works
Kieley & Mueller, Inc.
Marine-Galligan Co., Inc.
Marsh, Jas. P., & Co.
McAlear Mfg. Co.
Monash-Younker Co., Inc.
Mueller Co.
Mueller Steam Specialty Co., Inc.
National Radiator Corp.
New York Air Valve Corp.
O-E Specialty Mfg. Co.
Page, Wm. H., Boiler Co.
Pierce, Butler & Pierce Mfg. Corp.
Powers Regulator Co.
Rome Brass Radiator Corp.
Russell, W. A., & Co.
Smith, H. B., Co., The
Sterling Engineering Co.
Trane Co., The
U. S. Radiator Corp.

Angle, Check and Globe

American Radiator Co.
Crane Co.
Davis, G. M., Regulator Co.
Dole Valve Co., The
Fairbanks Co., The
Grinnell Co., Inc.
Illinois Engineering Co.
Jenkins Bros.
Marine-Galligan Co., Inc.
Marsh Valve Co.
McAlear Mfg. Co.
Mueller Steam Specialty Co., Inc.
National Radiator Corp.
O-E Specialty Mfg. Co.
Pierce, Butler & Pierce Mfg. Corp.
Powers Regulator Co.
Trane Co., The
U. S. Radiator Corp.

Anti-Siphon

Consolidated Ashcroft Hancock Co., Inc. (American Schaeffer & Budenberg Div.)

Automatic Gas Shut-off

American Radiator Co.

Back-Pressure

Bell & Gossett Co.
Bishop & Babcock Sales Co., The
Consolidated Ashcroft Hancock Co., Inc. (American Schaeffer & Budenberg Div.)
Crane Co.
Davis, G. M., Regulator Co.
Illinois Engineering Co.
Jenkins Bros.
Kieley & Mueller, Inc.
Klipfel Mfg. Co.
Mason Regulator Co.
McAlear Mfg. Co.
Mueller Steam Specialty Co., Inc.
O-E Specialty Mfg. Co.
Stickle Steam Specialties Co.

Blow-Off

Consolidated Ashcroft Hancock Co., Inc. (American Schaeffer & Budenberg Div.)
Crane Co.
Davis, G. M., Regulator Co.
Fairbanks Co., The
Jenkins Bros.
Mueller Co.
Mueller Steam Specialty Co., Inc.
U. S. Radiator Corp.

Diaphragm

National Regulator Co.

Float

American Radiator Co.
Bell & Gossett Co.
Crane Co.
Davis, G. M., Regulator Co.
Illinois Engineering Co.
Kieley & Mueller, Inc.
Klipfel Mfg. Co.
Mason Regulator Co.
McAlear Mfg. Co.
Mueller Steam Specialty Co., Inc.
O-E Specialty Mfg. Co.
Stickle Steam Specialties Co.
Trane Co., The
U. S. Radiator Corp.

Gage

American Radiator Co.
Bishop & Babcock Sales Co., The
Crane Co.
Grinnell Co., Inc.
O-E Specialty Mfg. Co.
Stickle Steam Specialties Co.
U. S. Radiator Corp.

Gate

American District Steam Co.
American Radiator Co.
Crane Co.
Dole Valve Co., The
Fairbanks Co., The
Jenkins Bros.
Marine-Galligan Co., Inc.
Marsh, Jas. P., & Co.
Marsh Valve Co.
Milwaukee Valve Co.
National Radiator Corp.
O-E Specialty Mfg. Co.
U. S. Radiator Corp.

Graduating

American District Steam Co.
American Radiator Co.
Barnes & Jones
Bishop & Babcock Sales Co., The
Burnham Boiler Corp.
Crane Co.
Direct Control Valve Co.
Dole Valve Co., The
Dunham, C. A., Co.
Haines, William S., & Co.
Hoffman Specialty Co., Inc.
Illinois Engineering Co.
Jenkins Bros.
Johns-Manville Corp.
Kieley & Mueller, Inc.
Marine-Galligan Co., Inc.
Marsh, Jas. P., & Co.
Marsh Valve Co.
Mason Regulator Co.
McAlear Mfg. Co.
Milwaukee Valve Co.
Monash-Younker Co., Inc.
National Radiator Corp.
O-E Specialty Mfg. Co.
Sarco Co., Inc.
Sterling Engineering Co.
Trane Co., The
U. S. Radiator Corp.
Vapor Engineering Co., Inc.
Warren Webster & Co.

Hot Water

American Radiator Co.
Barnes & Jones
Burnham Boiler Corp.
Consolidated Ashcroft Hancock Co., Inc. (American Schaeffer & Budenberg Div.)
Crane Co.
Davis, G. M., Regulator Co.
Dole Valve Co., The
Fairbanks Co., The
Finn Pump, M. J., Mfg. Co.
Jenkins Bros.
Marsh, Jas. P., & Co.
Marsh Valve Co.
National Radiator Corp.
Pierce, Butler & Pierce Mfg. Corp.
U. S. Radiator Corp.

Magnetic

Absolute Con-tac-tor Corp.
American Radiator Co.

Modulating

American District Steam Co.
American Radiator Co.
Barnes & Jones
Bishop & Babcock Sales Co., The
Burnham Boiler Corp.
Crane Co.
Direct Control Valve Co.
Dole Valve Co., The
Dunham, C. A., Co.
Haines, William S., & Co.
Hoffman Specialty Co., Inc.
Illinois Engineering Co.
Jenkins Bros.
Kieley & Mueller, Inc.
Marine-Galligan Co., Inc.
Marsh, Jas. P., & Co.
Marsh Valve Co.
McAlear Mfg. Co.
Monash-Younker Co., Inc.
O-E Specialty Mfg. Co.
Pierce, Butler & Pierce Mfg. Corp.
Sarco Co., Inc.
Sterling Engineering Co.
Trane Co., The
U. S. Radiator Corp.
Vapor Engineering Co., Inc.
Warren Webster & Co.

Catalogue Data of Manufacturers listed can be located by referring to pages 841 to 844

Packless

American District Steam Co.
American Radiator Co.
Barnes & Jones
Bishop & Babcock Sales Co., The
Burnham Boiler Corp.
Crane Co.
Davis, G. M., Regulator Co.
Direct Control Valve Co.
Dole Valve Co., The
Dunham, C. A., Co.
Haines, William S., & Co.
Illinois Engineering Co.
Marine-Galligan Co., Inc.
Marsh, Jas. P., & Co.
Marsh Valve Co.
McAlear Mfg. Co.
Milwaukee Valve Co.
Monash-Younker Co., Inc.
National Radiator Corp.
O-E Specialty Mfg. Co.
Pierce, Butler & Pierce Mfg. Corp.
Sarco Co., Inc.
Sterling Engineering Co.
Trane Co., The
U. S. Radiator Corp.
Warren Webster & Co.

Radiator

American District Steam Co.
American Radiator Co.
Barnes & Jones
Bishop & Babcock Sales Co., The
Burnham Boiler Corp.
Crane Co.
Davis, G. M., Regulator Co.
Direct Control Valve Co.
Dole Valve Co., The
Dunham, C. A., Co.
Fairbanks Co., The
Grinnell Co., Inc.
Haines, William S., & Co.
Hoffman Specialty Co., Inc.
Illinois Engineering Co.
Jenkins Bros.
Johns-Manville Corp.
Klipfel Mfg. Co.
Marine-Galligan Co., Inc.
Marsh, Jas. P., & Co.
Marsh Valve Co.
McAlear Mfg. Co.
Monash-Younker Co., Inc.
National Radiator Corp.
Herman Nelson Corp.
New York Air Valve Corp.
O-E Specialty Mfg. Co.
Pierce, Butler & Pierce Mfg. Corp.
Powers Regulator Co.
Russell, W. A., & Co.
Sarco Co., Inc.
Sterling Engineering Co.
Trane Co., The
U. S. Radiator Corp.
Vapor Engineering Co., Inc.
Warren Webster & Co.

Reducing

American District Steam Co.
Bell & Gossett Co.
Bishop & Babcock Sales Co., The
Consolidated Ashcroft Hancock Co., Inc. (American Schaeffer & Budenberg Div.)
Davis, G. M., Regulator Co.
Dunham, C. A., Co.
Illinois Engineering Co.
Jenkins Bros.
Kainer & Co.
Kieley & Mueller, Inc.
Klipfel Mfg. Co.
Mason Regulator Co.
McAlear Mfg. Co.
Mueller Co.
Mueller Steam Specialty Co., Inc.
O-E Specialty Mfg. Co.
Powers Regulator Co.
Stickle Steam Specialties Co.
Swartwout Co., The

Regrinding

Crane Co.
Fairbanks Co., The
Jenkins Bros.

Relief

American Radiator Co.
Bell & Gossett Co.
Burnham Boiler Corp.
Consolidated Ashcroft Hancock Co., Inc. (American Schaeffer & Budenberg Div.)
Crane Co.
Davis, G. M., Regulator Co.
Illinois Engineering Co.
Kainer & Co.
Kieley & Mueller, Inc.
Klipfel Mfg. Co.
McAlear Mfg. Co.
Mueller Co.
Mueller Steam Specialty Co., Inc.
Neptune Meter Co.
O-E Specialty Mfg. Co.
Petroleum Heat & Power Co.
Powers Regulator Co.
Stickle Steam Specialties Co.
Swartwout Co., The
Thrush, H. A., & Co.
Titusville Iron Works Co., The
U. S. Radiator Corp.

Return Line

Barnes & Jones
Bishop & Babcock Sales Co., The
Dunham, C. A., Co.
Fairbanks Co., The
Finn Pump, M. J., Mfg. Co.
Haines, William S., & Co.
Hoffman Specialty Co., Inc.
Illinois Engineering Co.
Jenkins Bros.
Kelly Brass Works
Kieley & Mueller, Inc.
Marine-Galligan Co., Inc.
Marsh, Jas. P., & Co.
McAlear Mfg. Co.
National Radiator Corp.
O-E Specialty Mfg. Co.
Sarco Co., Inc.
Stickle Steam Specialties Co.
Trane Co., The
U. S. Radiator Corp.
Warren Webster & Co.

Safety

American District Steam Co.
American Radiator Co.
Burnham Boiler Corp.
Consolidated Ashcroft Hancock Co., Inc. (American Schaeffer & Budenberg Div.)
Crane Co.
Davis, G. M., Regulator Co.
Jenkins Bros.
Marsh, Jas. P., & Co.
Mueller Co.
Mueller Steam Specialty Co., Inc.
National Radiator Corp.
New York Air Valve Corp.
O-E Specialty Mfg. Co.
Titusville Iron Works Co., The
U. S. Radiator Corp.

Steam Feed

Crane Co.
Davis, G. M., Regulator Co.
Fairbanks Co., The
Jenkins Bros.
Kieley & Mueller, Inc.
McAlear Mfg. Co.
Mueller Steam Specialty Co., Inc.
O-E Specialty Mfg. Co.
Swartwout Co., The

Thermostatic

American Radiator Co.
Barnes & Jones
Bishop & Babcock Sales Co., The
Burnham Boiler Corp.
Direct Control Valve Co.
Dole Valve Co., The
Dunham, C. A., Co.
Haines, William S., & Co.
Hoffman Specialty Co., Inc.
Illinois Engineering Co.
Jenkins Bros.
Kieley & Mueller, Inc.
Klipfel Mfg. Co.
Marsh, Jas. P., & Co.
McAlear Mfg. Co.
Milwaukee Valve Co.
Monash-Younker Co., Inc.
National Regulator Co.
New York Air Valve Corp.
O-E Specialty Mfg. Co.
Powers Regulator Co.
Sarco Co., Inc.
Stickle Steam Specialties Co.
Trane Co., The
U. S. Radiator Corp.
Vapor Engineering Co., Inc.

Vacuum

American District Steam Co.
American Radiator Co.
Barnes & Jones
Bell & Gossett Co.
Bishop & Babcock Sales Co., The
Burnham Boiler Corp.
Crane Co.
Davis, G. M., Regulator Co.
Dole Valve Co., The
Dunham, C. A., Co.
Finn Pump, M. J., Mfg. Co.
Haines, William S., & Co.
Hoffman Specialty Co., Inc.
Illinois Engineering Co.
Jenkins Bros.
Kelly Brass Works
Klipfel Mfg. Co.
Marine-Galligan Co., Inc.
Marsh, Jas. P., & Co.
Marsh Valve Co.
McAlear Mfg. Co.
Monash-Younker Co., Inc.
Mueller Steam Specialty Co., Inc.
O-E Specialty Mfg. Co.
Russell, W. A., & Co.
Sarco Co., Inc.
Sterling Engineering Co.
Stickle Steam Specialties Co.
Titusville Iron Works Co., The
Trane Co., The
U. S. Radiator Corp.
Warren Webster & Co.

Vapor

American District Steam Co.
American Radiator Co.
Barnes & Jones
Bishop & Babcock Sales Co., The
Burnham Boiler Corp.
Crane Co.
Davis, G. M., Regulator Co.

Catalogue Data of Manufacturers listed can be located by referring to pages 841 to 844

Dole Valve Co., The
Dunham, C. A., Co.
Finn Pump, M. J., Mfg. Co.
Haines, William S., & Co.
Hoffman Specialty Co., Inc.
Illinois Engineering Co.
Jenkins Bros.
Kieley & Mueller, Inc.
Marine-Galligan Co., Inc.
Marsh, Jas. P., & Co.
Marsh Valve Co.
McAlear Mfg. Co.
Monash-Younker, Co.
O-E Specialty Mfg. Co.
Sarco Co., Inc.
Sterling Engineering Co.,
Stickle Steam Specialties Co.
Trane Co., The
U. S. Radiator Corp.
Vapor Engineering Co., Inc.
Warren Webster & Co.

VAPOR HEATING SYSTEMS (*See Heating Systems, Steam*) (*Vapor*)

VENTILATING—Blowers (*See Blowers, Ventilating*)

Fans (*See Fans, Ventilating*)

Registers and Grilles (*See Registers and Grilles, Ventilating*)

Systems

Aerofin Corp.
American Blower Corp.
Bayley Blower Co.
Bentz Engineering Corp.
Buffalo Forge Co.
Carrier Engineering Corp.
Clarage Fan Co.
Cooling and Air Conditioning Corp.
De Bothezat Impeller Co.
Finn Pump, M. J., Mfg. Co.
Garden City Fan Co.
General Air Filters Corp.
Hirschman, W. F., Co., Inc.
Ilg Electric Ventilating Co.
Johnson Fan & Blower Co.
Knowles Mushroom Ventilator Co.
Midwest Air Filters, Inc.
National Air Filter Co.
Nesbitt, John J., Co.
New York Blower Co.
Niagara Blower Co.
Peerless Unit Ventilation Co., Inc.
Reed Air Filter Co.
Rome Brass Radiator Corp.
Schutte & Koerting Co.
Shipp, C. C., & Co.
Skinner Bros. Mfg. Co., Inc.
Stickle Steam Specialties Co.
Sturtevant, B. F., Co.
Swartwout Co., The
Trane Co., The
Wing, L. J., Mfg. Co.

VENTILATORS—Mushroom

American Blower Corp.
American Foundry & Furnace Co.
Buckeye Blower Co., The
Clarage Fan Co.
Knowles Mushroom Ventilator Co.
New York Blower Co.
Sturtevant, B. F., Co.

Roof

American Foundry & Furnace Co.
Buckeye Blower Co., The
Buffalo Forge Co.
Hirschman, W. F., Co., Inc.
Ilg Electric Ventilating Co.
Johns-Manville Corp.
New York Blower Co.
Niagara Blower Co.
O-E Specialty Mfg. Co.
Shipp, C. C., & Co.
Skinner Bros. Mfg. Co., Inc.
Sturtevant, B. F., Co.
Swartwout Co., The

Window

Buckeye Blower Co., The
De Bothezat Impeller Co.
Reed Air Filter Co.
Sturtevant, B. F., Co.

VENTS—Air

American Radiator Co.
Auer Register Co.
Bishop & Babcock Sales Co., The
Burnham Boiler Corp.
Crane Co.
Dole Valve Co., The
Dunham, C. A., Co.
Hirschman, W. F., Co., Inc.
Hoffman Specialty Co., Inc.
Marsh, Jas. P., & Co.
McAlear Mfg. Co.
O-E Specialty Mfg. Co.
Russell, W. A., & Co.
Sarco Co., Inc.
Trane Co., The
Tuttle & Bailey Mfg. Co.

WARM-AIR FURNACES (*See Furnaces, Warm Air*)

WARM-AIR HEATING SYSTEMS (*See Heating Systems, Warm Air*)

WARM-AIR REGISTERS (*See Registers, Warm Air*)

WATER COLUMNS (*See Columns, Water*)

WATER COOLED GRATES (*See Grates*)

WATER GAGES (*See Gages, Water*)

WATER FEEDERS (*See Feeders Water*)

WATER HEATERS (*See Heaters*)

WATER METERS (*See Meters, Water*)

WATER MIXERS (*Thermostatic*) (*See Mixers*)

WATER-PROOF CEMENT (*See Cement, Water Proof*)

WATER PURIFICATION
United States Ozone Co.

WATER SOFTENERS
Crane Co.
Finn Pump, M. J., Mfg. Co.

WATER SYSTEMS (*See Systems, Water*)

WEATHER STRIPS—Metal
Higgin Mfg. Co.

Catalogue Data of Manufacturers listed can be located by referring to pages 841 to 844

Index to Advertisers

AMERICAN SOCIETY of HEATING and VENTILATING ENGINEERS GUIDE 1929

	Page
Absolute Con-Tac-Tor Corp., Elkhart, Ind.	594
Aerofin Corp., 850 Frelinghuysen Ave., Newark, N. J.	666–668
Alberger Heater Co., 218 Chicago St., Buffalo, N. Y.	642
American Blower Corp., Detroit, Mich.	599
American District Steam Co., N. Tonawanda, N. Y.	596
American Foundry & Furnace Co., Bloomington, Ill.	595
American Gas Products Corp., 376 Lafayette St., New York, N. Y.	523
American Radiator Co., 40 West 40th St., New York, N. Y.	509–522, 664–665
American Steam Pump Co., Battle Creek, Mich.	715
Ames Iron Works, Oswego, N. Y.	558
Ames Pump Co., Inc., 90 West St., New York, N. Y.	716
Armstrong Cork & Insulation Co., 24th St. and Allegheny River, Pittsburgh, Pa.	614, 686–687
Armstrong Machine Works, 352 Maple St., Three Rivers, Mich.	740
Auer Register Co., 3608 Payne Ave., Cleveland, Ohio	738
Automatic Burner Corp., 312 N. May St., Chicago, Ill.	583
E. B. Badger & Sons Co., 75 Pitts St., Boston, Mass.	597
Ballard Oil Equipment Co., 124 Branford Place, Newark, N. J.	584
Banner Rock Products Co., Alexandria, Ind.	688–689
Barnes & Jones, 128 Brookside Ave., Jamaica Plain, Mass.	741
Bayley Blower Co., 784 Greenbush St., Milwaukee, Wis.	600
Bell & Gossett Co., 3000 Wallace St., Chicago, Ill.	643
Bentz Engineering Corp., 661 Frelinghuysen Ave., Newark, N. J.	495
Bigelow Co., The, 92 River St., New Haven, Conn.	524–525
Bishop & Babcock Sales Co., 4901–4915 Hamilton Ave., Cleveland, Ohio	742
Buckeye Blower Co., 435 W. Town St., Columbus, Ohio	601
Buffalo Forge Co., 490 Broadway, Buffalo, N. Y.	602
Buffalo Steam Pump Co., 490 Broadway, Buffalo, N. Y.	717
Builders Iron Foundry, 9 Codding St., Providence, R. I.	707
Burnham Boiler Corp., Irvington-on-Hudson, N. Y.	526
Samuel Cabot, Inc., 141 Milk St., Boston, Mass.	692
Carrier Engineering Corp., 850 Frelinghuysen Ave., Newark, N. J.	496–497
Carrier Lyle Corp., 39 Cortlandt St., New York, N. Y.	650–651
Celotex Co., 645 N. Michigan Ave., Chicago, Ill.	690–691
Chicago Pump Co., 2336 Wolfram St., Chicago, Ill.	718–719
Circulair Heat, Inc., 215 Central Ave., Louisville, Ky.	618–619
Clarage Fan Co., Kalamazoo, Mich.	603
Clip-Bar Mfg. Co., 1119 Roy St., Philadelphia, Pa.	729
Coatesville Boiler Works, Coatesville, Pa.	527
Combustion Specialties Corp., 250 West 54th St., New York, N. Y.	743
Consolidated Ashcroft Hancock Co., Inc., (American Schaeffer and Budenberg Corp., Division) 338 Berry St., Brooklyn, N. Y.	677
Cooling & Air Conditioning Corp., The, 11 West 42nd St., New York, N. Y.	498
Copper Radiator Sales Corp., Imperial Building, Schenectady, N. Y.	732–733
Crane Co., 836 S. Michigan Ave., Chicago, Ill.	804–805

	Page
D. & T. Mfg. Co., 3001 La Salle St., St. Louis, Mo	672
Davis Engineering Corp., 90 West St., New York, N. Y	644
G. M. Davis Regulator Co., 407 Milwaukee Ave., Chicago, Ill	744
De Bothezat Impeller Co., Inc., 1922 Park Ave., New York, N. Y	604
Direct Control Valve Co., 332 S. Michigan Boul., Chicago, Ill	806–807
Dole Valve Co., 1913 Carroll Ave., Chicago, Ill	808
C. A. Dunham Co., 450 E. Ohio St., Chicago, Ill	745–754
Economy Pumping Machinery Co., 3431 West 48th Place, Chicago, Ill	720–721
Edge Moor Iron Co., Edge Moor, Del	528–529
Ellison Draft Gage Co., 214 W. Kinzie St., Chicago, Ill	616–617
Excelso Products Corp., 65 Clyde Ave., Buffalo, N. Y	645
Fairbanks Co., 393 Lafayette St., New York, N. Y	809
M. J. Finn Pump Mfg. Co., 435 Fifth Ave., Pittsburgh, Pa	722–723
Fitzgibbons Boiler Co., Inc., 570 Seventh Ave., New York, N. Y	530–531
Flax-Li-Num Insulating Co., Wabash & Hampden Sts., St. Paul, Minn	694–695
O. E. Frank Heater & Engrg. Co., Inc., 20 Milburn St., Buffalo, N. Y	646
Frost Manufacturing Co., The, 1530 Henderson St., Galesburg, Ill	532–533
Garden City Fan Co., 332 S. Michigan Ave., Chicago, Ill	605
General Air Filters Corp., 369 Lexington Ave., New York, N. Y	504
General Electric Co., 1 River Road, Schenectady, N. Y	710–711
Grinnell Co., Inc., 275 W. Exchange St., Providence, R. I	657–663
Wm. S. Haines & Co., 12th and Buttonwood Sts., Philadelphia, Pa	764
Hardinge Brothers, Inc., 4149 Ravenswood Ave., Chicago, Ill	585
Harrisburg Star Boiler Corp., 15 Park Row, New York, N. Y	538
Healy-Ruff Co., 791 Hampden Ave., St. Paul, Minn	731
Heating & Ventilating Magazine, 243 West 39th St., New York, N. Y	714
Heggie-Simplex Boiler Co., Joliet, Ill	534–535
Herbert Boiler Co., Root and La Salle Sts., Chicago, Ill	536–537
Higgin Mfg. Co., Newport, Ky	708–709
E. Vernon Hill Co., 121 N. Clark St., Chicago, Ill	678
W. F. Hirschman Co., Inc., 220 Delaware Ave., Buffalo, N. Y	816–817
Hoffman Specialty Co., Inc., 25 West 45th St., New York, N. Y	620–621, 755–761
Ilg Electric Ventilating Co., 2850 N. Crawford Ave., Chicago, Ill	606
Illinois Engineering Co., 21st St. and Racine Ave., Chicago, Ill	762–763
Insulating Products Corp., 280 Madison Ave., New York, N. Y	684
Insulite Co., The, Builders Exchange, Minneapolis, Minn	693
Jenkins Brothers, 80 White St., New York, N. Y	810
Johns-Manville Corp., 292 Madison Ave., New York, N. Y	680–683
Johnson Fan & Blower Co., 1319 Lake St., Chicago, Ill	607
Johnson Service Co., 149–159 E. Michigan St., Milwaukee, Wis	794–798
Kainer & Co., 771 Mather St., Chicago, Ill	673
Kelly Brass Works, 226–232 W. Ontario St., Chicago, Ill	766–767
Kewanee Boiler Corp., Kewanee, Ill	539–545
Kieley & Mueller, Inc., 34 West 13th St., New York, N. Y	765
Klipfel Mfg. Co., 2641 W. Harrison St., Chicago, Ill	768–769
Knowles Mushroom Ventilator Co., 202 Franklin St., New York, N. Y	502–503

	Page
Langenberg Mfg. Co., 4549 N. Euclid Ave., St. Louis, Mo	615
Leader Iron Works, 3010 N. Jasper St., Decatur, Ill	546
Little Giant Mfg. Co., The, 1927 Nicollet Ave., Minneapolis, Minn	730
MacAndrews & Forbes Co., Third and Jefferson Sts., Camden, N. J	696–697
Marine-Galligan Co., Inc., 1822 Ludlow St., Philadelphia, Pa	770
Jas. P. Marsh & Co., 114–124 S. Clinton St., Chicago, Ill	772–773
Marsh Valve Co., Dunkirk, N. Y	812–815
Mason Regulator Co., Boston, Mass	771
Masonite Corp., 111 W. Washington St., Chicago, Ill	700
May Oil Burner Corp., 3500 E. Biddle St., Baltimore, Md	586–587
McAlear Mfg. Co., 1901 S. Western Ave., Chicago, Ill	774
McCord Radiator & Mfg. Co., 2587 E. Grand Blvd., Detroit, Mich	669
McDonnell & Miller, 400 N. Michigan Ave., Chicago, Ill	582
McQuay Radiator Corp., 35 E. Wacker Drive, Chicago, Ill	626–627
Midwest Air Filters, Inc., Bradford, Pa	505
Milwaukee Valve Co., Burrell and Chase Sts., Milwaukee, Wis	775
Mogul Machine Co., 608 Witherspoon Bldg., Philadelphia, Pa	598
Molby Boiler Co., Inc., 420 Lexington Ave., New York, N. Y	548–549
Monash-Younker Co., Inc., 1315 W. Congress St., Chicago, Ill	776–777
Monitor Boiler Co., 1505 Race St., Philadelphia, Pa	547
Mueller Co., Decatur, Ill	674
L. J. Mueller Furnace Co., 200 Reed St., Milwaukee, Wis	561
Mueller Steam Specialty Co., 502 West 126th St., New York, N. Y	778
Nash Engineering Co., The, S. Norwalk, Conn	724–725
National Air Filter Co., 5130 Ravenswood Ave., Chicago, Ill	506
National Radiator Corp., 221 Central Ave., Johnstown, Pa	550–552
National Regulator Co., 2311 Knox Ave., Chicago, Ill	799
Herman Nelson Corp., The, Moline, Ill	628–629
Neptune Meter Co., 50 East 42nd St., New York, N. Y	675
John J. Nesbitt, Inc., State Rd. and Rhawn St., Holmesburg Jct., Philadelphia, Pa.	630–633
Newport Boiler Co., 529 S. Franklin St., Chicago, Ill	553
New York Air Valve Corp., 476 Broome St., New York, N. Y	811
New York Blower Co., The, 3169 Shields Ave., Chicago, Ill	608
Niagara Blower Co., 673 Ontario St., Buffalo, N. Y	499–501
O-E Specialty Mfg. Co., 8-12 Keefe Ave., Milwaukee, Wis	779
Oil City Boiler Works, Seneca St., Oil City, Pa	554
Pacific Steel Boiler Corp., Waukegan, Ill. and Bristol Pa	556–557
Wm. H. Page Boiler Co., 200 Madison Ave., New York, N. Y	555
Pantasote Co., Inc., 250 Park Ave., New York, N. Y	698–699
Patterson-Kelley Co., The, 99 Park Ave., New York, N. Y	647
Peerless Unit Ventilation Co., Inc., 718–34 Crescent Ave., Bridgeport, Conn	634–636
Petroleum Heat & Power Co., 511 Fifth Ave., New York, N. Y	588–592
Pierce, Butler & Pierce Mfg. Corp., 41 East 42nd St., New York, N. Y	559
Powers Regulator Co., 2719 Greenview Ave., Chicago, Ill	800–803
Frank Prox Co., Terre Haute, Ind	566

	Page
Reed Air Filter Co., Inc., 202 Central Ave., Louisville, Ky.	507
Richardson & Boynton Co., 260 Fifth Ave., New York, N. Y.	560–561
Richmond Radiator Co., 1480 Broadway, New York, N. Y.	562–565
Ric-wiL Co., Union Trust Bldg., Cleveland, Ohio	685
Rome Brass Radiator Corp., 1 East 42nd St., New York, N. Y.	734–737
Rome-Tourney Radiator Co., Rome, N. Y.	670
W. A. Russell & Co., 5037 Grand Central Terminal, New York, N. Y.	780
Sarco Co., Inc., 183 Madison Ave., New York, N. Y.	782–783
Schutte & Koerting Co., 1154 Thompson St., Philadelphia, Pa.	671
C. C. Shipp & Co., 230 E. Ohio St., Indianapolis, Ind.	652–656
Skidmore Corp., 1535 Dayton St., Chicago, Ill.	726
Skinner Bros. Mfg. Co., Inc., 1490 S. Vandeventer Ave., St. Louis, Mo.	624–625
H. B. Smith Co., Westfield, Mass.	568–571
Smith Twin Tubular Boiler Co., 42 E. Allen St., Philadelphia, Pa.	567
Spencer Heater Co., Williamsport, Pa.	572–573
Sprayo-Flake Co., 56 S. Bay St., Milwaukee, Wis.	701
Stanwood Corp., The (P. O. Box 821), Cincinnati, Ohio	574–575
Sterling Engineering Co., 1626 Holton St., Milwaukee, Wis.	784–785
Stewart Inso Board Co., St. Joseph, Mo.	702
Stickle Steam Specialties, 2215 Valley Ave., Indianapolis, Ind.	781
Stockham Pipe & Fittings Co., Birmingham, Ala.	713
B. F. Sturtevant Co., 36 Hyde Park, Boston, Mass.	609
The Swartwont Company, 18551 Euclid Ave., Cleveland, Ohio	818
Webster Tallmadge & Co., Inc., 50 Church St., New York, N. Y.	793
Taylor Instrument Cos., 95 Ames St., Rochester, N. Y.	679
Thatcher Co., The, 39–41 St. Francis St., Newark, N. J.	576
Thermidaire Corp., 2441-45 Charlotte, St., Kansas City, Mo.	637
H. A. Thrush & Co., Peru, Ind.	676
Titusville Iron Works Co., The, Titusville, Pa.	577
Trane Co., The, La Crosse, Wis.	622–623, 638, 727, 786–787
Tuttle & Bailey Mfg. Co., 441 Lexington Ave., New York, N. Y.	739
United States Gypsum Co., 300 W. Adams St., Chicago, Ill.	703
United States Ozone Co., 500 N. Dearborn St., Chicago, Ill.	712
United States Radiator Corp., 133 E. Grand River Ave., Detroit, Mich.	578–579
Universal Gypsum & Lime Co., 111 W. Washington St., Chicago, Ill.	706
Vapor Engineering Co., 489 Fifth Ave., New York, N. Y.	788
Vinco Co., Inc., The, 75 Vesey St., New York, N. Y.	581
Warren Webster & Co., 17th and Federal Sts., Camden, N. J.	789–791
Weil-McLain Co., 641 W. Lake St., Chicago, Ill.	580
Westco-Chippewa Pump Co., Front and Gaines Sts., Davenport, Ia.	728
Whiting Corp., Harvey, Ill. (Joseph Harrington Co.)	508
Whitlock Coil Pipe Co., The, 20 South St., Hartford, Conn.	648–649
L. J. Wing Mfg. Co., 59 Seventh Ave., New York, N. Y.	610–612
Winslow Boiler & Engineering Co., 844 Rush St., Chicago, Ill.	593
Wood Conversion Co., Cloquet, Minn.	704–705
Wright-Austin Co., 315 W. Woodbridge St., Detroit, Mich.	792
York Heating & Ventilating Corp., 16th and Sansom Sts., Philadelphia, Pa.	613, 639–641

Roll of Membership

AMERICAN SOCIETY *of* HEATING *and* VENTILATING ENGINEERS

1929

Contains Lists of Members Arranged Alphabetically and Geographically also Lists of Officers and Committees, Past Officers and Local Chapter Officers

Corrected to December 1, 1928

Published at the Headquarters of the Society

29 West 39th Street, New York, N. Y.

Officers and Council

AMERICAN SOCIETY *of* HEATING *and* VENTILATING ENGINEERS

1928

President.....A. C. WILLARD, Urbana, Ill.
First Vice-President.....THORNTON LEWIS, Philadelphia, Pa.
Second Vice-President.....L. A. HARDING, Buffalo, N. Y.
Treasurer.....W. E. GILLHAM, Kansas City, Mo.
Secretary.....A. V. HUTCHINSON, New York, N. Y.

Council

A. C. WILLARD, *Chairman*
THORNTON LEWIS, *Vice-Chairman*

One Year	*Two Years*	*Three Years*
F. PAUL ANDERSON	W. H. CARRIER	H. H. ANGUS
J. J. KISSICK	C. V. HAYNES	N. W. DOWNES
E. B. LANGENBERG	JOHN HOWATT	ROSWELL FARNHAM
J. F. MCINTIRE	W. T. JONES	F. B. ROWLEY.
H. LEE MOORE		

Committees of the Council

Executive: Thornton Lewis, *Chairman;* J. F. McIntire, H. Lee Moore.
Finance: W. T. Jones, *Chairman;* J. F. McIntire, Thornton Lewis.
Membership: Roswell Farnham, *Chairman;* W. E. Gillham, C. V. Haynes.
Publication: L. A. Harding, *Chairman;* N. W. Downes, H. H. Angus.

Advisory Council

F. Paul Anderson, *Chairman;* Henry Adams, Homer Addams, R. P. Bolton, S. E. Dibble, W. H. Driscoll, H. P. Gant, John Gormly, John F. Hale, H. M. Hart, E. Vernon Hill, J. D. Hoffman, S. A. Jellett, D. D. Kimball, S. R. Lewis, J. I. Lyle, J. R. McColl, D. M. Quay, C. L. Riley, W. G. Snow, C. B. J. Snyder, F. R. Still.

Research Department

Committee on Research: S. R. Lewis, *Chairman;* E. B. Langenberg, *Vice-Chairman;* F. C. Houghten, *Director;* O. P. Hood, *Ex-Officio Member.* W. H. Carrier, S. E. Dibble, C. F. Eveleth, H. P. Gant, E. B. Langenberg (1 year); Philip Drinker, S. R. Lewis, F. D. Mensing, W. A. Rowe, A. C. Willard (2 years); A. R. Acheson, D. S. Boyden, R. V. Frost, L. A. Harding, F. B. Rowley (3 years).

Executive Committee: S. R. Lewis, *Chairman;* H. M. Hart, E. B. Langenberg, A. C. Willard.

Research Endowment Fund: A. C. Willard, *Chairman;* F. P. Anderson, Thornton Lewis, W. E. Gillham, W. T. Jones.

Coordinated Research: J. C. Fitts, *Chairman* (Nat'l. Assn. H. & P. Contrs.); R. M. Conner (American Gas Association); R. G. Creviston (Plumbing & Heating Industries Bureau).

Committees—1928

Technical Advisory Committees

Temperature, Humidity and Motion: W. H. Carrier, *Chairman;* W. A. Rowe, Perry West, Philip Drinker, Dr. Arthur Meyer.

Infiltration: G. L. Larson, *Chairman;* D. K. Boyd, L. B. Lent, A. P. Kratz.

Heat Transmission: L. A. Harding, *Chairman;* F. B. Rowley, A. J. Wood, J. C. Peebles.

Pipe Sizes for Heating Systems: H. M. Hart, *Chairman;* C. V. Haynes, S. E. Dibble, R. C. Morgan, R. S. Franklin.

Air Cleaning Devices: F. B. Rowley, *Chairman;* H. C. Murphy, E. V. Hill, Albert Buenger, A. M. Goodloe, H. E. Birkholz.

Maximum Boiler Output: L. S. O'Bannon, *Chairman;* L. E. Seeley, Alfred Kellogg Percy Nicholls.

Atmospheric Dust and Smoke: E. B. Langenberg, H. C. Murphy, E. V. Hill; *Ex-Officio Members,* F. C. Houghten, S. R. Lewis.

Radiation: F. D. Mensing, *Chairman;* R. A. Wolff, C. H. B. Hotchkiss.

Garage Ventilation: E. K. Campbell, *Chairman;* Thornton Lewis, W. H. Carrier, E. B. Langenberg.

Special Committees

Guide Publication Committee: Perry West, *Chairman;* W. H. Carrier, C. V. Haynes, *Vice-Chairmen;* S. R. Lewis, *Chairman, Committee on Research.*

Committee on Meetings Program: F. B. Rowley, *Chairman;* John Howatt, W. H. Carrier.

Committee on Code for Testing Unit Heaters: D. E. French, L. C. Soule, W. A. Rowe, H. W. Page.

Committee for Industrial Unit Heater Association: G. E. Otis, *Chairman;* J. A. Shrock, O. K. Dyer.

Committee on Rating and Selection of Low-Pressure Heating Boilers: Alfred Kellogg, *Chairman;* F. C. Houghten, Percy Nicholls, L. E. Seeley, S. R. Lewis.

Committee on Code of Heating & Ventilating: L. A. Harding, *Gen. Chairman.*

Sub-Com. I.	Definition of Terms	F. Paul Anderson, *Chm.*
Sub-Com. II.	Ventilation Requirements for Public Buildings	E. Vernon Hill, *Chm.*
Sub-Com. III.	Requirements for Heating Buildings	A. C. Willard, *Chm.*
Sub-Com. IV.	Direct Steam or Hot-Water Radiation	R. V. Frost, *Chm.*
Sub-Com. V.	Indirect Steam or Hot-Water Radiation	L. C. Soule, *Chm.*
Sub-Com. VI.	Heating Boiler Capacity	J. F. McIntire, *Chm.*
Sub-Com. VII.	Warm Air Furnace Heating	J. D. Hoffman, *Chm.*
Sub-Com. VIII.	Design of Chimneys and Flues	J. R. McColl, *Chm.*
Sub-Com. IX.	Pipe Sizes for Steam Heating	J. A. Donnelly, *Chm.*
Sub-Com. X	Pipe Sizes for Hot-Water Heating	W. S. Timmis, *Chm.*
Sub-Com. XI.	Air Ducts for Ventilation	C. A. Booth, *Chm.*
Sub-Com. XII.	Air Washers and Humidifiers	W. H. Carrier, *Chm.*
Sub-Com. XIII.	Pumps for Heating Systems	Perry West, *Chm.*
Sub-Com. XIV.	Standard Symbols for Drawings	J. H. Walker, *Chm.*

Officers of Local Chapters

1928-29

Cleveland

Headquarters, Cleveland

Meets: Second Friday in Month

President, CHAS. F. EVELETH
2341 Carneige Ave.

Secretary, EARL L. HEINLE
1364 East 34th Street

Illinois

Headquarters, Chicago

Meets: Second Monday in Month

President, H. G. THOMAS
549 W. Washington Blvd.

Secretary, C. W. DE LAND
211 N. Desplaines St.

Kansas City

Headquarters, Kansas City, Mo.

Meets: First Monday in Month

President, HERMAN C. HENRICI
430 West 58th Street

Secretary, RAY B. MASON
2014 Wyandotte Street

Massachussetts

Headquarters, Boston

Meets: First Monday in Month

President, E. C. WHITAKER
35 Sherborn Street, Arlington, Mass.

Secretary, J. W. BRINTON
1003 Statler Bldg.

Michigan

Headquarters, Detroit

Meets: First Monday after the 10th of the Month

President, W. A. ROWE
6004 Russell Street

Secretary, E. H. CLARK
606 Michigan Theatre Bldg.

Minnesota

Headquarters, Minneapolis

Meets: Second Monday in Month

President, A. J. HUCH
312 S. Third Street

Secretary, D. M. FORFAR
1004 Marquette Ave.

New York

Headquarters, New York

Meets: Third Monday in Month

President, H. B. HEDGES
149 Broadway

Secretary, E. B. JOHNSON
154 Wardwell Ave., W. New Brighton, S. I.

Western New York

Headquarters, Buffalo

Meets: First Monday in Month

President, C. A. EVANS
218 Lexington Ave.

Secretary, TOM NOVOTNEY
McKinley Bldg.

Ontario

Headquarters, Toronto, Can.

Meets: First Monday in Month

President, E. B. SHEFFIELD
11 Brant St.

Secretary, J. PATERSON
155 College Street

Pacific Northwest

Headquarters, Seattle, Wash.

Meets: Second Thursday in Month

President, LYLE DUDLEY
1800 Ninth Ave., S.

Secretary, E. O. EASTWOOD
University of Washington

Philadelphia

Headquarters, Philadelphia

Meets: Second Thursday in Month

President, R. V. FROST
1326 Markley Street, Norristown, Pa.

Secretary, A. J. NESBITT
State Road and Rhawn Street

Pittsburgh

Headquarters, Pittsburgh

Meets: First Monday in Month

President, F. A. GUNTHER
1007 Diamond Bk. Bldg.

St. Louis

Headquarters, St. Louis

Meets: First Wednesday in Month

President, L. WALTER MOON
3834 Oliver Street

Secretary, R. M. ROSEBROUGH
4246 Forest Park Blvd.

Wisconsin

Headquarters, Milwaukee

Meets: Third Monday in Month

President, W. F. NOLL
University of Wis., Madison

Secretary, V. A. BERGHOEFER
1640 Holton Street

Roll of Membership

AMERICAN SOCIETY *of* HEATING *and* VENTILATING ENGINEERS

1928-29

HONORARY MEMBERS

BALDWIN, WM. J. (1915), New York, N. Y. (Deceased May 7, 1924.)
BILLINGS, DR. J. S. (1896), New York, N. Y. (Deceased March 10, 1913.)
GORMLY, JOHN (Charter Member), Norristown, Pa.
NEWTON, C. W. (Charter Member), Baltimore, Md. (Deceased August 6, 1920.)

LIST OF MEMBERS IN GOOD STANDING

Arranged Alphabetically—All Grades

(Asterisk indicates authorship of papers)

(Junior 1916; Associate 1918; 1923) indicates, Elected Junior Member 1916; Elected Associate Member 1918; Elected Member 1923.

(Pres. 1923) indicates, Elected President in 1923 and is now a Presidential Member.

A

ABBOUD, Alfred, (Junior 1924), Pres. and Treas., (for mail), Alfred Abboud & Co., Inc., 45 Bromfield St., Boston, and Greendale Ave., Needham, Mass.

ABEL, D. Morgan, (Junior 1928), Research Engr., (for mail), York Htg. & Vtg. Corp., Bridgeport, Montgomery Co., and 700 Stanbridge St., Norristown, Pa.

ABRAHAMSON, Paul, (1927), Secy., (for mail), Advance Heating Co., 117–19 N. Desplaines St., and 1440 Rosemont Ave., Chicago, Ill.

ABRAMS, Abraham, (Junior 1924), Secy. and Treas., (for mail), Berman Rathe Corp., 155 East 128th St., and 640 West 153rd St., New York, N. Y.

ACHESON, Albert R., (1919), Consulting Engr., (for mail), 601 Eckel Theatre Bldg., and 852 Ostrom Ave., Syracuse, N. Y.

ADAMS, Benjamin, (1919), Dist. Mgr., (for mail), American Blower Co., 612 Otis Bldg., Philadelphia, and 3006 W. Coulter St., Queen Lane Manor, Philadelphia, Pa.

ADAMS, Charles W., (1920), Vice-Pres., (for mail), The Daly Co., 1635 Blake St., and Denver Athletic Club, Denver, Colo.

ADAMS, Henry, (Charter Member; Presidential Member), (Pres. 1899; Board of Managers 1894; Council 1895; 1898; 2nd Vice-Pres. 1897), Consulting Engr., (for mail), 1263-1269 Calvert Bldg., and 609 West 40th St., Baltimore, Md.

ADDAMS, Homer, (Charter Member; Presidential Member), (Council 1915-1925; Treas. 1915-1922; 1st Vice-Pres. 1923; Pres. 1924), Pres., (for mail), Kewanee Boiler Co., Inc., 570 Seventh Ave., New York, N. Y. and 405 High St., Germantown, Pa.

ADDY, Edward, (1923), Supervising Engr., Board of Education, 155 College St., and 31 Deloraine St., Toronto, Ont., Can.

ADLER, Alphonse A.,* (1921), Consulting Engr., (for mail), 9 Murray St., New York, N. Y., and 35 Stewart Ave., Arlington, N. J.

ADRIANSE, Paul R., (1923), Sales Engr., Buffalo Forge Co., 368 Rockefeller Bldg., Cleveland, and 3231 E. Overlook Rd., Cleveland Heights, O.

AEBERLY, John J., (1928), Chief Division of Ventilation, Department of Health, City of Chicago, Room 704, City Hall, and (for mail), 6259 Holbrook St., Chicago, Ill.

AHERN, Thos. L., (Junior 1923), Vice-Pres., (for mail), John F. Ahern Co., 80 S. Portland St., and 157 Sixth St., Fond du Lac, Wis.

AHLFF, Albert A., (Associate 1918; 1923), Dist. Mgr., Spencer Heater Co., 259 Delaware Ave., and (for mail), 521 Crescent Ave., Buffalo, N. Y.

ALEXANDER, Alfred D., (1915), Consulting Engr., 19 S. LaSalle St., Chicago, and (for mail), 168 Marion St., Oak Park, Ill.

ALEXANDER, Charles H., (1920), Prop., Chas. H. Alexander Co., 101 Campau Ave., N.W., and 532 Paris Ave., S.E., Grand Rapids, Mich.

ALGER, Richard W., (1911), Vice-Pres. and Treas., (for mail), Marye, Alger & Alger, Inc., Archts, 801-6 Walton Bldg., and 40 Fifteenth St., N.E., Atlanta, Ga.

ALLAN, Chas. D., (1920), Consulting Engr., (for mail), 228 N. LaSalle St., and 4526 Dover St., Chicago, Ill.

ALLEN, Harry D., (1917), Htg. and Vtg. Contracting., (for mail), Harry D. Allen 2940 W. Lake St., and 1640 N. Tuna Ave., Chicago, Ill.

ALLEN, W. Harwell, (Junior 1910; 1911), Pres., State Htg. & Power Co., 272 Walnut St., and (for mail), 878 Kensington Place, Memphis, Tenn.

ALLINSON, Orrie H., (1915), Jobstown, N. J.

ALT, Harold L.,* (1913), Chief Engr., Chas. S. Leopold, Consulting Engr., 213 S. Broad St., and (for mail), 867 N. Beechwood St., Philadelphia, Pa.

ALVORD, Arthur M., (1926), Pres., (for mail), Alvord & Swift, Grand Central Terminal, New York, and 240 Hamilton Ave., New Rochelle, N. Y.

AMES, Charles Fordyce, (Associate 1928), Vice-Pres. and Gen. Mgr., Ames Pump Co., Inc., 90 West St., New York, N. Y.

AMMERMAN, Charles R., (1916), Consulting Engr., (for mail), 925 Continental Bk. Bldg., and 3908 Guilford Ave., Indianapolis, Ind.

ANDEL, Frank J., (1922), Pres. and Mgr., (for mail), Andel & Co., 4630 N. Lamon Ave., and 7512 Eastlake Ter., Chicago, Ill.

ANDEREGG, R. H., (1920), Chief Engr. and Mgr. Pump Dept., Trane Co., and (for mail), 625 S. Eighth St., La Crosse, Wis.

ANDERSON, C. A., (1916), Dist. Mgr., (for mail), Ilg Elec. Vtg. Co., 326 Commercial Trust Bldg., Philadelphia, and 218 W. Washington Lane, Germantown, Philadelphia, Pa.

ANDERSON, F. Paul,* (1921), (Presidential Member), (Council 1924-26; 2nd Vice-Pres. 1925; 1st Vice-Pres. 1926; Pres. 1927), Dean, College of Engrg., and Prof. Mech. Engrg., (for mail), Univ. of Kentucky, and 409 E. Main St., Lexington, Ky.

ANDERSON, Phil Emanuel, (Associate 1926), Buyer, Htg. Dept., (for mail), Farwell, Ozmun, Kirk & Co., Second and Jackson Sts., and 1160 Orange St., St. Paul, Minn.

ANDERSON, S. A., Jr., (1909), Owner, Anderson Bros., 1307 Adams Ave., and (for mail), P. O. Box 486, La Grande, Ore.

ANDRESEN, A. W., (1926), Crane Co., 400 Third Ave., N., and (for mail), 5311 Penn Ave., S., *Minneapolis, Minn.*

ANGUS, Harry H.,* (1918), Consulting Engr., 2 Bloor St., W., and (for mail), 34 Farnham Ave., Toronto, Ont., Can.

ARCHER, Frank Sibley, (Junior 1926), Dist. Repr., (for mail), Kewanee Boiler Co., Inc., 311 Jackson Bldg., Buffalo, and 56 Berryman Drive, Snyder, N. Y., via Buffalo.

ARENBERG, Milton K., (Associate 1920), Sales Engr., (for mail), Ilg Elec. Vtg. Co., 324 W. Monroe St., Chicago, and 199 Roger Williams Ave., Highland Park, Ill.

ARKLEY, L. M.,* (1922), Prof. Mech. Engrg., (for mail), Queen's University, and 22 Kensington Ave., Kingston, Ont., Can.

ARMAGNAC, Arthur S., (Associate 1907; 1914), Editor, (for mail), The Heating & Ventilating Magazine, 243 West 39th St., New York, N. Y., and 375 Upper Mountain Ave., Upper Montclair, N. J.

ARMSPACH, Otto W.,* (1919), Vice-Pres., (for mail), E. Vernon Hill Co., 121 N. Clark St., Chicago, and Villa Park, Ill.

ARMSTRONG, Harold Melotte, (Associate 1928), Asst. Mgr., (for mail), American Radiator Co., 1344 Broadway, and 2921 Webb Ave., Detroit, Mich.

ARNOLD, Robt. S., (Junior 1922; Associate 1926), Dist. Mgr., (for mail), York Htg. & Vtg. Corp., 16th and Sansom Sts., Philadelphia, Pa.

ARTHUR, H. W., (Associate 1920), Htg. Engr. and Salesman, The Trane Co., 3030 Euclid Ave., and (for mail), 3223 Riverside Ave., Cleveland, O.

ARTHUR, John M., Jr., (1923), Industrial Engr., Kansas City Power & Light Co., Kansas City, Mo., and 3311 State Ave., Kansas City, Kan.

ASCHER, Norman C., (Associate 1928), Mgr., Indianapolis Br., U. S. Radiator Corp., 516 Board of Trade Bldg., Indianapolis, Ind.

ASHENHURST, Harold S.,* (Associate 1926), Consulting Engr., 6519 Algonquin Ave., Chicago, Ill.

ASHENHURST, Harold S., (Associate 1926), Insulation Engr., Universal Gypsum & Lime Co., Conway Bldg., and 6519 Algonquin Ave., Chicago, Ill.

ASHLEY, Edward E., (1912), Mech. Engr., Starrett & Van Vleck, 393 Seventh Ave., New York, N. Y., and (for mail), P. O. Box 118, Noroton Heights, Conn.

ASTON, James, (1919), Metallurgical Engr., (for mail), A. M. Byers Co., 235 Water St., Pittsburgh, and 50 Forest Ave., Ben Avon, Pa.

ATKINSON, Raymond E., (Junior 1923; Associate 1928), Engr., C. A. Dunham Co., 450 E. Ohio St., Chicago, and (for mail), P. O. Box 245, Arlington Heights, Ill.

ATKINSON, Robert E., (1897), (Board of Governors 1907), Consulting Engr., 81 Binns Rd., Liverpool, Eng.

ATWATER, Lyman W., (1923), Htg. Engr., Wm. H. Curtin Mfg. Co., 331 Adams St., and (for mail), 552 Rugby Rd., Brooklyn, N. Y.

AUSTIN, Frank L., (1914), Archt., 240 College St., Burlington, Vt.

AUSTIN, William E., (1909), Mgr., (for mail), Natl. Radiator Co., 3032 Norfolk St., Cor. Summit, and 107 Overbrook Rd., Richmond, Va.

AXEMAN, James E., (Junior 1925), Sales Engr., Spencer Heater Co., Williamsport, Pa., and (for mail), 346 Brooks Ave., Rochester, N. Y.

B

BABBITT, Edward C., (1923), Engr., (for mail), Snyder, Babbitt & Mathews, 16 E. Broad St., Columbus, and 135 N. Ardmore Rd., Bexley, Columbus, O.

BACHLER, Harry C., (Junior 1921; 1927), C. F. Bachler & Son, 139 N. Fourth St., Philadelphia, Pa.

BACHLER, Leonard J., (1918), Engr., Molby Boiler Co., 420 Lexington Ave., and (for mail), 55 West 49th St., New York, N. Y.

BACKSTROM, Russell E., (Junior 1928), Testing Engr., Wood Conversion Co., Cloquet, Minn.

BACKUS, Theodore H. L., (1916), Htg. and Vtg. Engr., (for mail), Schumacher & Backus, 308-12 S. Main St., and 1018 Vaughn St., Ann Arbor, Mich.

BAETZ, Henry, (1919), Chief Engr., (for mail), Skinner Bros. Mfg. Co., 1440 S. Vandeventer Ave., and 5854 Etzel Ave., St. Louis, Mo.

BAGNALL, George A., (1926), Mgr. Htg. Dept., (for mail), Hendrie & Bolthoff Mfg. & Supply Co., 1635 17th St., and 4601 East 26th Ave., Denver, Colo.

BAHNSON, Frederic F.,* (1917), Chief Engr. and Partner, (for mail), The Bahnson Co., 1001 S. Marshall St., and 28 Cascade Ave., Winston-Salem, N. C.

BAILEY, Edward P., Jr., (1925), Pres., (for mail), The Bryant Heater & Mfg. Co., 17825 St. Clair Ave., and 10510 Park Lane, Cleveland, O.

BAILEY, Jos. H., (Junior 1923; Associate 1927; 1928), Sales Engr., (for mail), Carrier Engrg. Corp., 1032 Burnham Bldg., and 1640 Pratt Bldg., Chicago, Ill.

BAIN, James G., (1920), 73 W. Holly St., Phoenix, Ariz.

BAIRD, F. X., (Associate 1925), Johns-Manville, Inc., 292 Madison Ave., New York, N. Y.

BAKER, Clyde Harold, (1928), Estimator, J. W. Partlan, 14290 Goddard Ave., and (for mail), 1130 Fernhill Ave., Detroit, Mich.

BAKER, Edward V., (1923), Silent Partner, J. H. Olson, 4012 State St., and (for mail), 3654 Wentworth Ave., Chicago, Ill.

BAKER, Emerit E., (1910), Pres., Kewanee Boiler Co., Kewanee, Ill.

BAKER, H. W. H., (1918), Managing Dir., Twyford, Ltd., 18 Council Rd., Tientsin, China.

BAKER, Howard C., (1921), Pres., (for mail), The Howard C. Baker Co., 213 Michigan St., and 15 Columbia St., Toledo, O.

BAKER, Roland Henry, (Associate 1924; 1928), Pres. and Treas., (for mail), R. H. Baker Co., Inc., Kendall Sq. Bldg., Cambridge, and 40 Bay State Rd., Belmont, Mass.

BALDWIN, W. H., (1921), Br. Mgr., (for mail), C. A. Dunham Co., 2994 E. Grand Blvd., and 2662 W. Grand Blvd., Detroit, Mich.

BALSINGER, Harry David, (1927), Salesman, American Radiator Co., 1008 Pine St., St. Louis, Mo.

BAMPTON, C. Morton, (1919), Vice-Pres. and Secy., (for mail), Ideal Htg. Co., 915 Gates Ave., Brooklyn, N. Y., and Hollis Park Gardens, L. I., N. Y.

BARKER, Arthur H.,* (1906), Consulting Engr., (for mail), 100 Victoria St., Westminster, London, S. W. 1, and Oakhill House, Beckenham, Kent, Eng.

BARNES, Arthur F., (1921), Mech. Engr. and Owner, (for mail), Texas Engr. Co., 925 Elec. Bldg., Houston, Tex.

BARNES, Arthur R., (1924), State Architect's Office, P. O. Box 273, Topeka, Kan.

BARNES, Elmer Raymond, (1928), Estimator, Eichler Htg. Co., 2010 Railway Exch., and (for mail), 4444 Beethoven, St. Louis, Mo.

BARNES, Ralph B., (1927), Owner, Barnes Htg. Co., 210 Harrison St., (and (for mail), 800 Carpenter Ave., Oak Park, Ill.

BARNSTEINER, Alphons, (Associate 1926), Elec. Engr., (for mail), Westinghouse Elec. & Mfg. Co., and 212 Rowland Ave., Mansfield, O.

BARNUM, Marvin C., (Associate 1928), Sales Mgr. and Engr., Zephyr Washed Air Co., 1124 Harmon Place, Minneapolis, Minn.

BARR, George W., (1905), Dist. Repr., Aerofin Corp., 1822 Land Title Bldg., Philadelphia, Pa., and (for mail), 24 Chatfield Rd., Bronxville, N. Y.

BARRE, Louis S., (1925), Consulting Engr., 32 Ave de la Motte, Picquet, 32, Paris, France.

BARROWS, Charles E., (Associate 1921), Sales Engr., (for mail), Crane Co., 156 N. Jefferson St., Chicago, and 1041 Ridge Blvd., Evanston, Ill.

BARRY, Patrick I., (1920), Managing Director, (for mail), M. Barry & Co., 4 Marlboro St., and 2 Clarence Ter., St. Luke's, Cork, Ireland.

BARTH, Herbert E., (1920), American Blower Co., 50 Church St., New York, N. Y.

BARTLETT, Amos C., (1919), Dist. Mgr., (for mail), B. F. Sturtevant Co., 60 State St., Boston, and 10 Dumbarton Rd., Wollaston, Mass.

BARTLETT, C. Edwin, (1922), Pres., Bartlett & Co., Inc., 1938 Market St., and 3111 W. Coulter St., Philadelphia, Pa.

BARTLEY, John S., Jr., (1924) Archt., (for mail), 903 Pioneer Bk. Bldg., Waterloo, Ia.

BARTON, Royal Elton, (1922), Engr., (for mail), McLean & Cousens Co., 65 Chandler St., Boston, and 3 Fernald Ter., Dorchester, Mass.

BASSLER, Edwin M., (1923), Gen. Mgr., (for mail), D. J. Murray Mfg. Co., 1002 Third St., and 905 First St., Wausau, Wis.

BASTEDO, Albert E., (1919), Vice-Pres. and Treas., (for mail), Burnham Boiler Corp., Irvington, and 12 Wilson Place, Hastings-on-Hudson, N. Y.

BAUER, Henry C., (Associate 1928), Mgr., (for mail), H. C. Bauer Co., 42 E. Allen St., and 416 Wellesley Rd., Philadelphia, Pa.

BAUM, Albert L., (1916), Member of Firm, Jaros & Baum, 116 West 39th St., and (for mail), 255 West 108th St., New York, N. Y.

BAUMGARDNER, Carroll Miles, (1928), Br. Mgr., (for mail), U. S. Radiator Corp., 4004 Duncan Ave., and Guild Hall Apts., 4907 W. Pine Blvd., St. Louis, Mo.

BAYSE, Harry V., (1923), Pres., American Furnace Co., 2725 Morgan St., and 6959 Hancock Ave., St., Louis, Mo.

BEAHM, Robert B., 2nd, (1919), Treas., Eagan & Beahm, Inc., 304-6 Stephen Girard Bldg., Philadelphia, and Haverford, Pa.

BEASOM, George Reynold, (1927), Mfgr. Repr., 716 Terminal Bldg., and (for mail), 51 Brookdale Ave., Rochester, N. Y.

BEATTY, David J., (1918), Engr., Chas. Schneider Co., 492 East 163rd St., New York, and (for mail), 1274 New York Ave., Brooklyn, N. Y.

BEAURRIENNE, Auguste,* (1912), Contracting and Consulting Engr., 25 Rue des Marguettes, Paris, 12th Arr., France.

BEEBE, Frederick E. W., (Associate 1915), Sales Engr., (for mail), Johnson Service Co., 28 West 29th St., New York, N. Y., and 543 Clinton St., Elizabeth, N. J.

BEERY, Clinton E., (1913), Sales Engr., Kewanee Boiler Co., 822 Washington Blvd., Chicago, Ill.

BEGGS, William E., (1927), Vice-Pres., University Plbg. & Htg. Co., 3939 University Way and 3639 Palatine Ave., Seattle, Wash.

BEIGHEL, Howard Atlee, (Associate 1927), Mgr., (for mail), Herman Nelson Corp., 308 Commonwealth Bldg., Annex, Pittsburgh, and 3338 Latonia Ave., Dormont, Pittsburgh, Pa.

BEIRN, John U., (Junior 1928), Salesman, Hoffman Specialty Co., 25 West 45th St., New York, and (for mail), 210 Voorhees Ave., Buffalo, N. Y.

BELING, Earl H., (Junior 1925), Sales Engr., Warren Webster & Co., 549 W. Washington Blvd., Chicago, and (for mail), 142 N. Austin Blvd., Oak Park, Ill.

BEMAN, Myron C., (1926), Consulting Engr., (for mail), Beman & Candee, 607 White Bldg., 55 Granger Place., Buffalo, N. Y.

BENDER, Charles P., (1923), Partner, (for mail), C. and J. Bender, 1734 Flatbush Ave., and 2045 East 19th St., Brooklyn, N. Y.

BENEDICT, Everett R., (1926), Construction Engr., 500 East 102nd St., Cleveland, O.

BENNETT, George Garman, (1928), Serv. Engr., Standard Dry Kiln Co., P. O. Box 544, *Indianapolis, Ind.*, and (for mail), 1106 Springfield Ave., Urbana, Ill.

BENNETT, Irving T., (Junior 1927), Htg., (for mail), Metropolitan Engrg. Co., 1250 Atlantic Ave., and 234 East 42nd St., Brooklyn, N. Y.

BENNETT, Prescott D., (1926), Div. Sales Engr., (for mail), The Trane Co., 844 Rush St., and 7527 Ridge Blvd., Chicago, Ill.

BENNITT, George E., (1918), Consolidated Gas Co., 130 East 15th St., New York, N. Y.

BENTZ, Harry, (1915), Pres., (for mail), Bents Engrg. Corp., 661 Frelinghuysen Ave., Newark, and 18 Holland Ter., Montclair, N.J.

BERCHTOLD, Edward W., (Associate 1925-1927), Engr., Boston Consolidated Gas Co., 100 Arlington St., Boston, and (for mail), 29 Randolph St., S. Weymouth, Mass.

BERG, A. Herman, (1919), Pres., (for mail), Berg Htg. & Vtg. Co., 742 Laura Ave., and 140 N. Stafford, Huntington Park, Calif.

BERGHOEFER, Victor A., (Junior 1926), Secy., Sterling Engrg. Co., 1640 Holton St., and (for mail), 1104 Island Ave., Milwaukee, Wis.

BERGNER, William G., (Associate 1923), Secy., Plumbing & Heating Industries Bureau, Mercantile Bldg., Evansville, Ind., and (for mail), 616 N. Michigan Ave., Evanston, Ill.

BERMAN, Louis K., (1908), Secy., (for mail), Raisler Htg. Co., 129 Amsterdam Ave., and 515 West End Ave., New York, N. Y.

BERMEL, Alfred H., (Junior 1928), Htg. and Vtg. Engr., Guilbert & Betelle, Archts., Chamber of Commerce Bldg., and (for mail), 350 N. Sixth St., Newark, N. J.

BERRINGER, Sidney H., (1926), Sales Engr., Hoffman Specialty Co., Waterbury, Conn., and (for mail), 1217–50th St., Milwaukee, Wis.

BETTS, Howard M., (1927), Sr. Mech. Engr., Htg. and Vtg., (for mail), Dept. of Buildings, City of Minneapolis, 213 City Hall, and 4923 Russell Ave., S., Minneapolis, Minn.

BETZ, Harry D., (1928), Chief Engr., Air Conditioning Dept., General Refrigeration Co., 805 Delaware, and (for mail), 3819 Wyoming St., Kansas City, Mo.

BEVERLEY, R. Carter, (1905), Pres. and Treas., R. C. Beverley Htg. Co., Inc., 308 E. Main St., and (for mail), 3812 Chamberlayne Ave., Richmond, Va.

BEVIL, Alexander Thomas, (Junior 1927), Asst. Htg. Engr., Crane Co., 254 Court, and (for mail), 353 Walker Ave., Memphis, Tenn.

BEVINGTON, Warren Charles, (1928), Pres., (for mail), Bevington-Williams, Inc., 1134-39 Indiana-Pythian Bldg., and Apt. 9, 327 E. Maple Rd., Indianapolis, Ind.

BEYER, Jack E., (Junior 1924), Htg. and Vtg. Engr., Weiss Htg. & Plbg. Co., 5604 Cedar Ave., and (for mail), 1317 East 112th St., Cleveland, O.

BIDWELL, Raymond E., (Associate 1924), Vice-Pres. and Gen. Mfr. of Sales, The Kellogg-Mackay Co., 1351 West 37th Place, Chicago, Ill.

BILYEU, William F., (1927), Sales Mgr., The Trane Co., 600 S. Delaware Ave., Philadelphia, Pa., and (for mail), 110 Midway St., Riverton, N. J.

BINDER, Charles G., (1920), Mgr. Htg. Dept., Warren Webster & Co., 17th and Federal Sts., Camden, and (for mail), 115 Oak Ter., Merchantville, N. J.

BINDER, Irving, (Junior 1920; 1922), Estimator, Keasbey & Mattison, 60 Park Ave., Newark, N. J., and (for mail), 106 West 47th St., New York, N. Y.

BIRCH, Herbert R., (1922), Sales Engr., U. S. Radiator Corp., 101 Park Ave., and 875 West 181st St., New York, N. Y.

BIRKHOLZ, H. E., (Associate 1925), Vice-Pres., (for mail), National Air Filter Co., 5130 Ravenswood Ave., and 5066 N. Lincoln St., Chicago, Ill.

BIRRELL, Allan Lloyd, (Associate 1925), Equip. Engr., (for mail), Chapman & Oxley, 1608 Northern Ontario Bldg., and 201 Pacific Ave., Toronto, Ont., Can.

BISHOP, Charles R., (1901), (Council 1916), Vice-Pres., (for mail) Caloroil Burner Corp., 225 West 34th St., New York, and 412 Locust St., Lockport, N. Y.

BISHOP, Frederick R., (1921), Mgr., Garland Furnace Div., Detroit-Michigan Stove Co., 6950 E. Jefferson Ave., and (for mail), 4018 Pingree Ave., Detroit, Mich.

BJERKEN, Maurice H., (Associate 1927), Dist. Mgr., (for mail), Hoffman Specialty Co., 531 S. Seventh St., and 4952–17th Ave., S., Minneapolis, Minn.

BLACK, Edgar Newbold, 3rd, (1922), Br. Mgr., Kewanee Boiler Co., Inc., 803 Land Title Bldg., Philadelphia, and (for mail), 111 Woodside Rd., Haverford, Pa.

BLACK, Fred C., (1919), Pres., (for mail), F. C. Black Co., 622 W. Randolph St., and 4535 N. Ashland Ave., Chicago, Ill.

BLACK, George E., (1915), Factory Mgr., H. H. Robertson Co., Ambridge, and (for mail), 709 Broad St., Sewickley, Pa.

BLACK, Harry G., (1917), Htg. Contractor, (for mail), P. Gormly Co., 155 N. Tenth St., and 927 North 65th St., Philadelphia, Pa.

BLACK, John J., (Junior 1922; Associate 1925), Pres., (for mail), John Black & Son, Inc., 20 Nassau St., and 15 Murray Place, Princeton, N. J.

BLACKHALL, Wilmot R., (1922), Partner, (for mail), McKellar & Blackhall, 1104 Bay St., and 332 Waverly Rd., Toronto, Ont., Can.

BLACKMAN, Alfred O., (1911), Consulting Engr., (for mail), 33 West 42nd St., New York, N. Y., and Stamford, Conn.

BLACKMORE, F. H., (1923), Mgr., Operating Dept., (for mail), U. S. Radiator Corp., P. O. Box 686, and 2322 Tuxedo Ave., Detroit, Mich.

BLACKMORE, George C., (Charter Member), Pres., Automatic Gas Steam Radiator Co., 301 Brushton Ave., Pittsburgh, and (for mail), Edgewood, Pittsburgh, Pa.

BLACKMORE, J. J.,* (Charter Member), Council 1896; Bd. of Gov. 1904; Secy. 1914-15), 32 West 40th St., New York, N. Y.

BLACKMORE, Norman Lawther, (1928), Sales Mgr., (for mail), Automatic Gas Steam Radiator Co., 301 Brushton Ave., and 103 Biddle St., Pittsburgh, Pa.

BLAKE, Albert Henry, (1926), Dist. Mgr., (for mail), Sheldons, Ltd., 119 Pender St., W., and 3261 Second Ave., W., Vancouver, B. C.

BLANDING, Geo. H., (1919), Sales Engr., Johnson Service Co., 1355 W. Washington Blvd., Chicago, and (for mail), 729 Hayes Ave., Oak Park, Ill.

BLANEY, Charles A., (1914), Wheeler-Blaney Co., 223 N. Burdick St., Kalamazoo, Mich.

BLANKIN, Merrill F., (Junior 1919; Associate 1926), Vice-Pres., Haynes Selling Co., Inc., 2013 Sansom St., and (for mail), 3328 W. Penn St., Philadelphia, Pa.

BLESSED, William A., (Junior 1927), Mech. Engr., Smith, Hinchman & Grylls, 800 Marquette Bldg., Detroit, and (for mail), 78 Amherst Rd., Pleasant Ridge, Mich.

BLEST, Frank S., (1923), Treas., (for mail), Blest & Emery Co., Inc., 784 Coney Island Ave., and 226 Argyle Rd., Brooklyn, N. Y.

BLISS, Sherwood C., (Associate 1926), Industrial Engr., 2894 Delaware Ave., and (for mail), 30 Argonne Drive, Kenmore, N. Y.

BLOMFELDT, Allen A., (1914), Secy., (for mail), Texo Sales Co., Inc., 241 Walnut St., Cincinnati, O., and 100 Mayo Ave., Clifton, Ky.

BLOOM, Samuel C., (1915), Sole Owner, (for mail), S. C. Bloom & Co., 53 W. Jackson St., and 1953 East 72nd St., Chicago, Ill.

BOALES, William G., (Associate 1923), Asst. Sales Mgr., (for mail), Hoffman Specialty Co., Webster Hall, and 1130 Parker Ave., Detroit, Mich.

BOCK, Bernard, (Junior 1927), Mech. Draftsman, Edward L. Larkin, 1457 Broadway, New York, and (for mail), 121-41 Farmers Ave., St. Albans, L. I., N. Y.

BODDINGTON, William P., (1927), Mgr., (for mail), Canadian Powers Regulator Co., 106 Lombard St., and 18 Larkin Crescent, Toronto, Ont., Can.

BOEKER, Carl Herman, (1926), Vice-Pres. and Htg. Engr., Central Supply Co., Inc., 838-856 Main Ave., and (for mail), 39 High St., Passaic, N. J.

BOGARDUS, George W., (1925), Br. Mgr., (for mail), Kewanee Boiler Co., 707 Hubbell Bldg., and 215 Foster Drive, Des Moines, Iowa.

BOGATY, Hermann S., (1921), Chief Engr. (for mail), Proctor & Schwartz, Inc., Seventh and Tabor Rd., and 5230 North 15th St., Philadelphia, Pa.

BOISCLAIR, Hugh Cappes, (1926), Dist. Repr., (for mail), Warren Webster & Co., Protective Life Bldg., and 1512 Fulton Ave., Birmingham, Ala.

BOLLING, Esten,* (Junior 1918; 1921), P. O. Box 46, East Orange, N. J.

BOLSINGER, Raymon C., (1916), Secy., (for mail), Fowler & Wolf Mfg. Co., 521 Bulletin Bldg., Philadelphia, Pa., and 238 E. Madison Ave., Collingswood, N. J.

BOLTON, Reginald Pelham,* (1897), (Presidential Member), (Pres. 1911), (Board of Governors 1901; 2nd Vice-Pres. 1903; 1st Vice-Pres. 1905-1910; Board of Governors 1912-1913), Pres., (for mail), R. P. Bolton Co., 116 East 19th St., and 638 West 158th St., New York, N. Y.

BONDY, Winfield S., (Junior 1926), Htg. Engr., Baker Smith & Co., Inc., 576 Greenwich St., New York, and (for mail), 1154–52nd St., Brooklyn, N. Y.

BOON, George, (1915), Pres., (for mail), Boon & Sample, Inc., 3008 Ludlow St., and 6428 Morris Park Rd., Philadelphia, Pa.

BOOTH, Charles A., (1917), Vice-Pres., (for mail), Buffalo Forge Co., 490 Broadway, and 142 Summit Ave., Buffalo, N. Y.

BOOTH, Harry N., (Associate 1917; 1924), Mgr., (for mail), New York Br., U. S. Radiator Corp., 101 Park Ave., New York, and 40 Manursing Ave., Rye, N. Y.

BORNEMANN, Walter A., (Junior 1923; 1924), Sales Engr., (for mail), Carrier Engr. Corp., 2021 Land Title Bldg., Philadelphia, and 123 W. Wharton Ave., Glenside, Pa.

BOSTAIN, James C., (1923), Sales and Service Engr., (for mail), Williamson Heater Co., 337 W. Fifth St., Cincinnati, O., and Kenton Hills, Covington, Ky.

BOSWIN, George A., (1917), Secy., (for mail), R. B. Haywood Co., 1714 Sheffield Ave., and 902 Diversey Parkway, Chicago, Ill.

BOWERS, A. F., (Associate 1919), Pres. and Treas., (for mail), Industrial Htg. & Engrg. Co., 490 Broadway, and 697 Hachett Ave., Milwaukee, Wis.

BOWERS, J. Sylvan, (1921), J. Sylvan Bowers Htg. Specialty Co., 2525a W. St. Louis Ave., St. Louis, Mo.

BOWLES, Potter, (Associate 1928), Dist. Repr., Hoffman Specialty Co., 2704 South Hill St., Los Angeles, and (for mail), 1234 El Mirado Drive., Pasadena, Calif.

BOWMAN, Howard A., (Associate 1926), Mgr., Sales Promotion, (for mail), American Radiator Co., 310 Second Ave., Pittsburgh, and 2706 Ocean Ave., South Hills Sta., Pittsburgh, Pa.

BOYD, D. Knickerbacker,* (1921), Consulting Archt. and Structural Standardist, (for mail), Structural Service Bureau, Otis Bldg., 112 South 16th St., and 27 E. Willow Grove Ave., Philadelphia, Pa.

BOYD, William R., (Junior 1924; Associate 1926), Htg. Sales Engr., Turner Supply Co., 8 W. Sixth St., and 320 East 19th St., Chester, Pa.

BOYDEN, Davis S.,* (1909), (Council 1917), Supt. Steam Htg. Service Dept., (for mail), Edison Elec. Illuminating Co., 39 Boylston St., Boston, and 72 Gardner St., Allston, Mass.

BOYNTON, Daniel Wilcox, (Associate 1927), Salesman, (for mail), International Heater Co., 27 State St., Boston, and 46 Powder House Rd., Medford, Mass.

BRABBEE, Chas. W.,* (1925), Dir. of the Institute of Thermal Research, (for mail), American Radiator Co., 675 Bronx River Rd., and 11 DeWitt Ave., Bronxville, N. Y.

BRACKEN, John Henry, (1927), Mgr., Special Insulation Dept., (for mail), The Celotex Co., 645 N. Michigan Ave., and 2929 Pine Grove Ave., Chicago, Ill.

BRADBURY, George L., (1921), Co-partner and Mgr., (for mail), Bradbury Bros. Htg. Co., 1219 Stout St., and 1254 Race St., Denver, Colo.

BRADFIELD, William W., (1926), Engr., 909 Michigan Trust Bldg., and 1352 Franklin St., S. E., Minneapolis, Minn.

BRADFORD, H. H., (Associate 1927), Salesman, Minneapolis Heat Regulator Co., 2753 Fourth Ave., and (for mail), 3504–14th Ave., S., Minneapolis, Minn.

BRADLEY, Eugene P.,* (1906), Pres., (for mail), Hester, Bradley Co., 4200 Forest Park Blvd., St. Louis, and 6935 Pershing Ave., University City, Mo.

BRADLEY, John T., (1908), (Bd. of Gov. 1911), Pres., (for mail), Bradley Htg. Co., 3834 Olive St., St. Louis, and 4 Yale Ave., *University City*, Mo.

BRADLEY, Royal H., (1915), Pres., (for mail), Kelsey Htg. Co., 277 James St., and 400 Oak St., Syracuse, N. Y.

BRAEMER, William G., (1915), Secy., (for mail), Universal Humidifier Corp., 808 Denckla Bldg., Philadelphia, Pa., and 421 Redman Ave., Haddonfield, N. J.

BRANDELES, H. J., (1921), Pres. and Mgr., (for mail), H. J. Brandeles Corp., 1602 Lincoln Ave., and 66 Prospect St., Utica, N. Y.

BRANDT, Ernst Hamilton, Jr., (1928), Partner, Chas. W. Christian, 1016 Independence Bldg., and (for mail), P. O. Box 292, Charlotte, N. C.

BRANIGIN, Harry L., (1926), Sales Mgr., (for mail), The Air Conditioning & Engineering Co., 2914 S. Jefferson Ave., and 4508 Shenandoah, St. Louis, Mo.

BRASCH, Harry Kenneth, (Associate 1926), 405 Kulien Bldg., Seattle, Wash.

BRASSINGTON, Arthur F., (Associate 1918), Htg. Engr., 520-24 West 41st St., New York, and (for mail), 337 Richmond Ave., Port Richmond, N. Y.

BRAUER, Roy, (1926), Htg. and Vtg. Engr., (for mail), The Schley & Nash Co., 712 Columbia Bank Bldg., Pittsburgh, and 2880 Glenmore Ave., Dormont, Pittsburgh, Pa.

BRAUN, Louis T., (1921), Secy., Chicago Master Steam Fitters Assn., 1213 Chamber of Commerce, and (for mail), 1418 Jonquil Ter., Chicago, Ill.

BRAYTON, William M., (1926), Engr., (for mail), Robert Gordon, Inc., 22 W. Austin Ave., and 1400 Lake Shore Drive, Chicago, Ill.

BRECKENRIDGE, L. P., (1920), "The Brackens," N. Ferrisburg, Vt.

BREEN, Jos. W., (1916), Htg. Engr., Wyalusing Ave. and Falion St., Philadelphia, Pa.

BREITENBACH, George C., (Junior 1928), Sales Engr., (for mail), The Trane Co., 330 Investment Bldg., and 1431 Chapin St., N. W., Washington, D. C.

BRENDER, Peter E., (1920), Chief Engr., Univ. of Mich. Hospital, Ann Arbor, and (for mail), 2111 Woodward Ave., Detroit, Mich.

BRENEMAN, R. B., (Junior 1927), Sales Engr., Armstrong Cork & Insulation Co., 232 Delaware Ave., Buffalo, N. Y.

BRESNAHAN, James J., (1919), Pres and Treas., James J. Bresnahan, Inc., 37-41 Pearl St., and 92 Linwood Ave., Buffalo, N. Y.

BREWSTER, Donald R., (1926), Natl. Lumber Mfgrs. Assn., (for mail), 1339 Bank of Commerce Bldg., and 349 Hawthorne St., Memphis, Tenn.

BRICKEY, Joel P., (Associate 1924), 665 S. Pearl St., Denver, Colo.

BRIDE, W. T., (Junior 1925; 1928), Supervising Engr., (for mail), Bridge, Grimes & Co., P. O. Box 373, and 116 E. Haverhill St., Lawrence, Mass.

BRIDGES, Frank G., (1919), 622 East 131 St., Cleveland, O.

BRINTON, Joseph W., (1920), Mgr. Boston Office, (for mail), American Blower Co., 1003 Statler Bldg., Boston, and 9 Summit Ave., Brookline, Mass.

BRODERICK, Joseph F., (Junior 1914; 1918), P. O. Box 388, Springdale, Conn.

BROGAN, James J., (Associate 1917), (for mail), Brogan & Co., 810 Race St., Philadelphia, and 6142 Lebanon Ave., Overbrook, Pa.

BRONSON, Carlos E., (1919), Mech. Engr., (for mail), Kewanee Boiler Co., and 311 McKinley Ave., Kewanee, Ill.

BROOKS, Thomas C., (1923), Pres. and Treas., T. C. Brooks Co., 101 W. Dedham St., Boston, Mass.

BROOM, Benjamin Alexander, (1914), Sales Promotion Engr., (for mail), Weil-McLain Co., 641 W. Lake St., and 5514 Blackstone Ave., Chicago, Ill.

BROWN, Alfred P., (1927), Sales Engr., (for mail), Alfred P. Brown, Inc., Dexter Horton Bldg., and The Rhododendron Apts., Seattle, Wash.

BROWN, Aubrey I., (1923), Asst. Prof. Htg. and Vtg., Ohio State University, and 45 E. Lakeview Ave., Columbus, O.

BROWN, Foskett,* (1926), Vice-Pres., (for mail), Gray & Dudley Co., 222 Third Ave., and 2314 West End Ave., Nashville, Tenn.

BROWN, John H., (1920), Mgr., (for mail), Keasbey & Mattison Co., 429 N. Washington Ave., and 3704 Blaisdell St., Minneapolis, Minn.

BROWN, Morris, (Junior 1928), Htg. Engr., Brown Bros., 610 W. Park St., and (for mail), 609 W. Park St., Dorchester, Mass.

BROWN, Robert H., (1926), Research Engr., (for mail), Parks-Cramer Co., 1102 Old South Bldg., Boston, and 78 Manthorne Rd., W. Roxbury, Mass.

BROWN, William Chester, (Associate 1928), Pres., The Brown Co., 1055 W. Baltimore Ave., Detroit, Mich.

BROWN, William H., (Associate 1923), Mgr. Brown Bros., 807–34th St., and (for mail), 1227 –22nd St., Milwaukee, Wis.

BROWNE, Alfred L., (1923), Repr., (for mail), Illinois Engrg. Co., 3514 Grand Central Terminal, New York, N. Y., and 253 Highland Rd., S. Orange, N. J.

BROWNELL, Chester D., (1923), Mgr. and Engr., (for mail), Reliable Plbg. & Htg. Co., 109 W. *University* Ave., and 307 W. White St., Champaign, Ill.

BROWNING, Hilbert K., (Junior 1926), Dist. Sales Rep., (for mail), A. M. Byers Co., 412 Shell Bldg., and 5941 Cabanne Ave., St. Louis, Mo.

BRUEGGEMAN, Arthur R., (1920), Pres., (for mail), The A. R. Brueggeman Co., 1212 Terminal Tower, Cleveland, and 17220 Aldersyde Drive, Shaker Village, Cleveland, O.

BRUNETT, Adrian L., (1923), Mech. Engr., P. O. Box 16, Rockville, Md.

BRUNNER, Herbert, (1924), Consulting Engr. and Pres., (for mail), Brunner Engr. Co., Inc., 41 West 69th St., New York, N. Y.

BRUNT, T. Bayard, (1917), Chief Engr. and Mgr., Mechanical Equipt. Co., 214 South 12th St., Philadelphia, Pa., and (for mail), 405 Eighth St., Riverton, N. J.

BRYANT, Alice G., Dr.,* (1921), 502 Beacon St., Boston, Mass.

BRYANT, Percy J., (1915), Chief Engr., (for mail), U. S. Military Academy, West Point, and 231 Carpenter Ave., Newburgh, N. Y.

BRYCE, Stephen D., (1921), Partner, (for mail), Bryce Htg. & Vtg. Co., 2016 North 14th St., and 2907 Rockwood Place, Toledo, O.

BUCK, Lucien, (1928), Mgr., Dryer Div., (for mail), James Hunter Mch. Co., and 188 Pleasant St., North Adams, Mass.

BUDER, Chas. G.,* (1919), Pres., (for mail), Fire-King Automatic Coal Burner Co., 407 Buder Bldg., St. Louis, and North Drive, Forrest Hills Park, Webster Groves, Mo.

BUEL, H. G., (Associate 1921), Vice-Pres., Tilghman Moyer Co., 141 N. Ninth St., and (for mail), 2135 Chew St., Allentown, Pa.

BUENGER, Albert,* (Junior 1917; 1920), Mech. Engr., C. H. Johnston, Archt., 360 Robert St., and 1666 Stanford Ave., St. Paul, Minn.

BUENSOD, Alfred C., (1918), Sales Engr., (for mail), Carrier Engrg. Corp., 39 Cortlandt St., and 125 West 12th St., New York, N. Y.

BULKELEY, Claude A.,* (1923), Chief Engr., (for mail), Niagara Blower Co., 673 Ontario St., and 84 W. Hazeltine Ave., Kenmore Station, Buffalo, N. Y.

BUNNELL, E. W., (Junior 1923; 1924), Consulting Engr., 509-510 American-Traders Bldg., Birmingham, Ala.

BURKE, Fletcher H., (1925), Consulting Engr., (for mail), Fletcher H. Burke, 677 Ellicott Sq., Buffalo, and Orchard Park, N. Y.

BURKE, George B., (1926), Vice-Pres., (for mail), Sarco Co., Inc., 205 W. Wacker Drive, Chicago, and 611 Ninth St., Wilmette, Ill.

BURNAP, Charles W., (1922), Herman Nelson Corp., 724 Commercial St., and 1105 Mechanic, Emporia, Kan.

BURNETT, Earle S., (1920), Mech. Engr., (for mail), Bureau of Mines, U. S. Helium Prod. Plant, P. O. Box 602, and 4005 W. Sixth St., Ft. Worth, Tex.

BURNS, Edward J., (1923), Htg. Engr., (for mail), H. Kelly & Co., 925 Plymouth Bldg., and 4716 Aldrich Ave., S., Minneapolis, Minn.

BURNS, Willard A., (1924), Collins & Burns Co., 4230 Lincoln Ave., and (for mail), 1728 Farwell Ave., Chicago, Ill.

BURRITT, Charles G., (Associate 1916), Mgr., (for mail), Johnson Service Co., 922 Second Ave., and Buckingham Hotel, Minneapolis, Minn.

BURT, John E., (1924), J. E. Burt & Son, 2442 South 16th St., Philadelphia, Pa.

BURTON, Clarence A., (1919), Mgr., (for mail), Kewanee Boiler Co., 2020 Wyandotte St., and 3534 Virginia Ave., Kansas City, Mo.

BUSHNELL, Carl D., (Associate 1921), Pres., (for mail), Bushnell Mchy. Co., 132 Seventh St., Pittsburgh, and 94 Pilgrim Rd., Rosslyn Farms, Carnegie, Pa.

BUTLER, Charles, (1920), 108½ W. Second St., Oklahoma City, Okla., and Hotel Sherman, Fourth and Hill Sts., Los Angeles, Calif.

BUTLER, Charles Willis, (Junior 1927), Sales Engr., (for mail), The American Blower Co., 1221 Boatmens Bk. Bldg., and 6306 Clayton, Rd., St. Louis, Mo.

BUTLER, Peter D., (1922), Salesman, U. S. Radiator Corp., 101 Park Ave., New York, N.Y. and (for mail), 127 Edgewater Ave., Grantwood, N. J.

BYRNES, Thomas F., (Junior 1924; Associate 1925), Htg. and Vtg. Engr., The Frederick Raff Co., 164 State St., and (for mail), 31 Clifford St., Hartford, Conn.

C

CADWELL, William H., (1916), Pres., (for mail), The Beaton & Cadwell Mfg. Co., P. O. Box 1012, and 130 W. Main St., New Britain, Conn.

CALAHAN, John J., (1915), Supervising Engr., (for mail), Board of Education, Administration Bldg., 2 Harrison Ave., and 78 Bartholdi Ave., Jersey City, N. J.

CALEB, David,* (1923), Engr., Kansas City Power & Light Co., (for mail), 1330 Grand Ave., and 141 Spruce St., Kansas City, Mo.

CALLAHAN, Michael J., (1914), Pres. and Treas., Peerless Unit Ventilation Co., 718-34 Crescent Ave., Bridgeport, Conn.

CALLAHAN, Thomas H., (Junior 1924; 1928), Pres., (for mail), Callahan Engrg. Co., Inc., 20 Grove St., and 8 Rutherford St., White Plains, N. Y.

CALLON, Harry, Jr., (Associate 1928), Mgr., (for mail), Callon Bros., 24 S. Alabama St., and 3001 East 38th St., Indianapolis, Ind.

CALVERT, Norman W.,* (1921), (for mail), Klipfel Mfg. Co., 2651 W. Harrison St., Chicago, and 839 Lake St., Oak Park, Ill.

CAMPBELL, Everett K.,* (1920), Pres. and Treas., (for mail), E. K. Campbell Htg. Co., 2445 Charlotte St., and 3717 Harrison Blvd., Kansas City, Mo.

CAMPBELL, Frank Barden, (Associate 1927), Own business, (for mail), Barclay-Campbell Co., 9 Murray St., New York, and 1205a Bergen St., Brooklyn, N. Y.

CAMPBELL, J. Packard, (Junior 1927; Associate 1928), Htg. Engr., The James Robertson Co., Ltd., P. O. Box 1000, St. John and 3 Dunn Ave., West St. John, N. B., Can.

CAMPBELL, Thomas Francis, (1928), Distributor, Minneapolis-Honeywell Regulators, (for mail), 1013 Penn Ave., and 1317 Penn Ave., Wilkinsburg, Pa.

CANTWELL, William T., (1920), Plbg. and Htg. Contracting, (for mail), 306 Bleecker St., and 1302 Brinckerhoff Ave., Utica, N. Y.

CAREY, James A., (1928), Gen. Sales Mgr., (for mail), York Htg. & Vtg. Corp., 16th St., Cor. Sansom St., Philadelphia, and Wynnewood, Pa.

CARLE, William E., (1926), Pres., (for mail), Carle-Boehling Co., 1641 W. Broad St., and 2220 Floyd Ave., Richmond, Va.

CARMAN, G. Gay, (Junior 1928), Pres. and Chief Engr., (for mail), Dykema, Carman & Dykema, Inc., 803 Grand Rapids Trust Bldg., and 900 Giddings Ave., S. E., Grand Rapids, Mich.

CARNAHAN, Glen C., (1924), James B. Clow & Sons, 201 N. Talman Ave., and (for mail), 5428 Woodlawn Ave., Chicago, Ill.

CARPENTER, R. H., (1921), Mgr., New York Office, (for mail), Nash Engr. Co., Graybar Bldg., 420 Lexington Ave., New York, and 10 Jefferson Ave., White Plains, N. Y.

CARR, Clifford H., (Associate 1924), Pres. and Mgr., (for mail), C. H. Carr Mchy. Co., 411 Mutual Bldg., and 5108 Main St., Kansas City, Mo.

CARRASCO, Saturnino, (Junior 1928), Mech. Engr., Monedo 944, Santiago, Chile, S. A.

CARRIER, Willis H.,* (1913), (Council 1923-26), Pres., Carrier Engrg. Corp., 750 Frelinghuysen Ave., Newark, and (for mail), Rensselaer Rd., Essex Fells, N. J.

CARROLL, W. J., (Associate 1925), Br. Mgr., Kewanee Boiler Co., 402½ Mich. Trust Bldg., and (for mail), 339 Burton St., S.E., Grand Rapids, Mich.

CARSTEN, W. H., (1923), Pres., (for mail), Majestic Furnace & Mfg. Co., 1723 Westlake Ave., N., and 4903 Second Ave., N. W., Seattle, Wash.

CARSTENS, Emil, (Junior 1922; Associate 1925), Salesman, H. B. Smith Co., 49th and Grays Ave., and 4615 N. Rosehill St., Philadelphia, Pa.

CARTY, Thomas, (1924), Pres., Carty Htg. Corp., 29 Audubon Ave., and 635 West 174th St., New York, N. Y.

CASEY, Byron L., (1921), Sales Engr., (for mail), Ilg Elec. Vtg. Co., 324 W. Monroe St., Chicago, and 423 N. Prospect Ave., Park Ridge, Ill.

CASH, Tidie T., (Associate 1925), Pres., (for mail), Cash Co., 240 Seventh Ave., S., and 4620 Colfax Ave., S., Minneapolis, Minn.

CASSELL, John D.,* (1913), Supt. of Bldgs., (for mail), Board of Public Education, Keystone School Bldg., 19th and Chestnut Sts., and 2007 Chestnut St., Philadelphia, Pa.

CASSERLY, T. D., (Associate 1923), Mech. Engr., Weil-McLain Co., Michigan City, Ind., and (for mail), 5339 Winthrop Ave., Chicago, Ill.

CASTIN, Laurence N., (1927), Htg. Contracting, 1212 Michigan Ave., Buffalo, N. Y.

CAVILEER, James V., (Associate 1921), Asst. Sales Mgr., (for mail), York Htg. & Vtg. Corp., 1541 Sansom St., and 7124 Ogontz Ave., Philadelphia, Pa.

CHADEAYNE, George D., (Junior 1924; Associate 1926), Engr., Gorton & Lidgerwood Co., 96 Liberty St., New York, and (for mail), 187 Sixth Ave., Brooklyn, N. Y.

CHADWICK, John Beaghen, (1926), Htg. and Vtg. Engr., Calico Printers Assn., Ltd., Bldg., Dept. P. O. Box 52, St. James Bldg., Oxford St., and (for mail), 11 Orville Drive, Burnage Hall Rd., Burnage, Manchester, England.

CHAISSON, Clarence H., (Junior 1926), Draftsman, C. S. Cox Engrg. Co., 625 Putnam Ave., Cambridge, Mass.

CHALLMAN, Samuel A., (1919), Director of School Bldgs., State Dept. of Education, State Capitol, St. Paul, and (for mail), 1107 Seventh St., S.E., Minneapolis, Minn.

CHAMBERS, William E., (Associate 1923), Htg. Contractor, 1025 Franklin St., Williamsport, Pa.

CHAPMAN, D. Witt, (1914), Consulting Engr., 427 Bond Bldg., Washington, D. C.

CHAPMAN, Frank T., (1909), (Board of Governors 1913; Council 1914-1916; 2nd Vice-Pres. 1915; 1st Vice-Pres. 1916), E. Davey Dodd, 137 Forest Ave., Glen Ridge, N. J.

CHAPPELL, Robert E., (1928), Industrial Engr., (for mail), The St. Louis County Gas Co., 231 W. Lockwood, Webster Groves, and 4920a McPherson, St. Louis, Mo.

CHAPPELL, T. A., (1926), Pres., Weldon Sheet Metal Works, Inc., Weldon, N. C.

CHASE, John M., (Associate 1916), Vice-Pres. (for mail), W. A. Case & Son Mfg. Co., 50 East 42nd St., and 468 Riverside Drive, New York, N.Y.

CHENOWETH, William H., (1911), Dist. Mgr., (for mail), Warren Webster & Co., 549 W. Washington St., Chicago, and 541 Keystone Ave., River Forest, Ill.

CHERRY, Lester A., (1921), Industrial Planning Corp., (for mail), 45 Court St., and 155 Euclid Ave., Hertel Sta., Buffalo, N. Y.

CHERVEN, Victor W., (Associate 1920; 1928), Chief Engr., (for mail), Holland Furnace Co., and 326 Maple Ave., Holland, Mich.

CHESTER, Thomas,* (1917), 1318 Cordova Rd., Pittsburgh, Pa.

CHEYNEY, C. C., (Associate 1925), Asst. Sales Mgr., Buffalo Forge Co., 490 Broadway, and (for mail), 90 Bryant St., Buffalo, N. Y.

CHILDRESS, Worthie Lee, (1925), Partner, E. G. Harris & Co., 3312 W. Cary St., and 609 West 27th St. Richmond, Va.

CHOFFIN, C. C., (1919), Secy. and Treas., W. J. Scholl & Co., Mahoning Ave. and Hogue St., and 450 Catalina Ave., Youngstown, O.

CHRISTIAN, Charles W., (1913), Owner, (for mail), Chas. W. Christian, Htg. & Vtg. Engr. & Contr., P. O. Box 292, 935 Providence Rd., and Myers Park, Charlotte, N. C.

CHURCH, Herbert John, (1922), Mgr., (for mail), Darling Bros., Ltd., 77 York St., Toronto, and 358 Main St., Weston, Ont., Can.

CLAFFEY, Edward J., (1913), Pres., (for mail), E. J. Claffey Co., 10 W. Illinois St., and 531 Roscoe St., Chicago, Ill.

CLARE, Fulton Warren, (1927), Mgr., (for mail), Clare & Co., 611 Bona Allen Bldg., and 1316 North Ave., N.E., Atlanta, Ga.

CLARK, E. Harold, (1922), Br. Mgr., J. D. Swartwout Co., 606 Michigan Theatre Bldg., and (for mail), 132 Pingree St., Detroit, Mich.

CLARK, Fred C., (1923), Pres., F. C. Clark Htg. Co., 5941 Baum Blvd., and 505 N. Sheridan Ave., Pittsburgh, Pa.

CLARK, Homer J., (1919), Dist. Mgr., B. F. Sturtevant Co., 1042 Wrigley Bldg., Chicago, Ill.

CLARK, William D., (1908), Htg. and Vtg. Engr., Richardson & Boynton Co., 260 Fifth Ave., New York, and (for mail), 8613–110th St., Richmond Hill, N. Y.

CLARK, W. H., (1921), Htg. Engr., Anchor Sanitary Co., 123 Third Ave., and 932 Woodbourne Ave., Pittsburgh, Pa.

CLARKE, Samuel S., (1909), Pres. and Mgr., (for mail), S. S. Clarke & Co., Ltd., 605 Second St., and 603 Second St., West Calgary, Alta, Can.

CLARKSON, Robert C., Jr., (1921), Asst. Engr., Turner Construction Co., 1713 Sansom St., and 821 South 49th St. Philadelphia, Pa.

CLARKSON, William B., (1919), Director of Research, King Vtg. Co., and (for mail), 216 Broadway, Owatonna, Minn.

CLEGG, Carl, (1922), Dist. Mgr., (for mail), American Blower Co., 311 Mutual Bldg., and 3321 Gillham Rd., Kansas City, Mo.

CLELAND, James E., (1925), Owner, (for mail), Cleland Engrg. Co., 208-19 Fifth St., and 73 N. Princeton Circle, Lynchburg, Va.

CLEMENT, E. R., (Associate 1924), In charge Htg. Dept., New Haven Plbg. Supply Co., 209 Meadow St., New Haven, and (for mail), 77 Richardson St., Bridgeport, Conn.

CLIFTON, Wm. F., (1923), Mgr., W. F. Clifton & Co., 313 Brook Ave., Toronto, Ont., Can.

CLOSE, Paul Dunham, (1928), Asst. Mgr., Bldg., Dept., The Celotex Co., 645 N. Michigan Ave., Chicago, and 508 S. Cuyler Ave., Oak Park, Ill.

CLOUD, Oscar E., (Associate 1924), Mgr., (for mail), Western Sheet Metal Works, 450 N. Main St., and 529 Madison Ave., Wichita, Kan.

CLOUGH, Leslie, (1922), Htg. and Vtg. Engr., 80 Boylston St., Boston, and 203 Pierce Rd., Weymouth, Mass.

CLOW, Milton T., (1926), Research Engr., (for mail), James B. Clow & Sons, 201 N. Talman Ave., Chicago, and 930 Columbian Ave., Oak Park, Ill.

CLUCAS, W. Frank, (1928), 483 Elmwood Ave., and (for mail), 81 Huntington Ave., Buffalo, N. Y.

COE, Ivan B., (1918), Pres., (for mail), Blower Systems Corp., 362 Plymouth Ave., S., and 122 Penhurst Ave., Rochester, N. Y.

COE, Ralph T., (1917), Partner, (for mail), The R. T. Coe Companies, 709 Gas and Elec. Bldg., and 236 Chili Ave., Rochester, N. Y.

COHAGEN, Chandler C., (1919), Archt., (for mail), McIver E. Cohagen, P. O. Box 1305, Heddin Bldg., and 127 Wyoming Ave., Billings, Mont.

COLBY, Clyde W., (1915), Pres., C. W. Colby & Co., 2341 Carnegie Ave., Cleveland, and 1755 Northfield Ave., E. Cleveland, O.

COLE, Grant E., (Associate 1925), Vice-Pres., Trane Co. of Can., Ltd., 439 King St., W., and (for mail), 128 Grenadier Rd., Toronto, Ont., Can.

COLEMAN, John B., (1920), Chief Engr., (for mail), Grinnell Co., Inc., 260 W. Exchange St., and 237 Cole Ave., Providence, R. I.

COLLAMORE, Ralph, (1904), (Bd. of Gov. 1913), Secy., Smith, Hinchman & Grylls, 800 Marquette Bldg., and (for mail), 679 Pingree Ave., Detroit, Mich.

COLLETTE, John R., (Associate 1928), Vice-Pres., (for mail), Pacific Steel Boiler Corp. of Ill., and 317 Glendenning Place, Waukegan, Ill.

COLLIER, William I., (1921), Consulting Engr., (for mail), W. I. Collier & Co., 522 Park Ave., Baltimore, and Ellicott City, Md.

COLLVER, Gordon L., (Junior 1927), Sales Engr., B. F. Sturtevant Co. of Can., Ltd., 1010 Lumsden Bldg., Toronto, and (for mail), 63 Beattie Ave., London, Ont., Can.

COMSTOCK, Glen Moore, (Associate 1926), Chief Engr., (for mail), Rush Machinery Co., 32 E. Carson St., Pittsburgh, and 134 College Ave., Beaver, Pa.

CONES, Benjamin, (1911), 2301 N. Knox Ave., Chicago, Ill.

CONNELL, Richard F., (1916), Mgr., (for mail), Capitol Testing Lab., U. S. Radiator Corp., 127 Campbell Ave., and 2970 Burlingame Ave., Detroit, Mich.

COOK, Benjamin F., (1920), Member of Firm, Cook & White, 308 Mutual Bldg., Kansas City, and (for mail), 170 Overton Ave., Independence, Mo.

COOK, Chester D., (1921), (for mail), D. F. Edwards Heating Co., 2340 Pine St., and 910 Boland Place, St. Louis, Mo.

COOK, Harris R., (Associate 1924), Dist. Mgr., (for mail), American Foundry & Furnace Co., 805–36th St., and 1121–44th St., Milwaukee, Wis.

COON, Thurlow E., (1916), Pres., The Coon-DeVisser Co., 2051 W. Lafayette, and (for mail) 826 Edison Ave., Detroit, Mich.

COOPER, Albert W., (Associate 1925), Mgr., Salt Lake Office, (for mail), Johnson Service Co., 610 McIntyre Bldg., and 2543 Highland Drive, Salt Lake City, Utah.

COOPER, Frank Irving, (1911), (Council 1914-1916), Pres., (for mail), Frank Irving Cooper Corp., 172 Tremont St., Boston, and Concord Rd., Wayland, Mass.

COOPER, Harry, (Associate 1924), Pres., (for mail), Harry Cooper Supply Co., 223 Water St., and 590 E. Walnut St., Springfield, Mo.

COOPER, John W., (Junior 1921; Associate 1925), Repr., (for mail), Buffalo Forge Co., 906 Chemical Bldg., and 5700 Clemens Ave., St. Louis, Mo.

COOPER, Thos. R., (1923), Shanghai Water Works Co., 69 Kiangse Rd., and 339 Yu Yuen Rd., Shanghai, China.

COOPER, Thomas W., (Associate 1922), Associate Mgr., (for mail), National Radiator Corp., 121 N. Broad St., and 5117 N. Mervine St., Philadelphia, Pa.

CORNELL, Harold, (Associate 1925), Salesman, Davies Supply Co., 6601 Grand Ave., Chicago, Ill.

CORNWALL, George T., (1919), Mgr., Boiler Dept., (for mail), Hitchings & Co., Spring and Louisa Sts., and 633 Madison Ave., Elizabeth, N. J.

COSGROVE, Wallace M., (1923), Vice-Pres., (for mail), American Radiator Co., 40 West 40th St., New York, N. Y., and 240 Ridgewood Rd., S. Orange, N. J.

COTTON, Roland M., (Associate 1928), Secy. Treas., (for mail), Roland M. Cotton Co., 1720 E. Tenth St., and R. R. H. Box 27-B, Indianapolis, Ind.

COUGHLIN, R. J., (1925), Dist. Mgr., B. F. Sturtevant Co., 1042 Wrigley Bldg., and (for mail), 8215 Maryland Ave., Chicago, Ill.

COUSENS, Walter S., (1924), Treas., McLean & Cousens Co., 65 Chandler St., Boston, and (for mail), 46 Shornecliff Rd., Newton, Mass.

COWARD, Herbert, (1921), Wash. Rep., (for mail), Buffalo Forge Co., 418 Washington Loan & Trust Bldg., Washington, D. C., and E. Falls Church, Va.

COWLES, Benjamin E., (1919), Htg. Engr., (for mail), Kellogg-Mackay Co., 824 S. Fourth St., Minneapolis, and 3711 Colfax Ave., N., N. Minneapolis, Minn.

COX, Christopher J., (1919), (for mail), C. J. Cox Engrg. Co., 625 Putnam Ave., Cambridge, and 1412 Commercial Ave., Allston, Mass.

COX, W. F., (1924), Specialty Engr., (for mail), Crane Co., 1532 Grand Ave., and 5212 Rockhill Rd., Kansas City, Mo.

COX, William W., (1923), Pres. and Mgr., (for mail); Heating Service Co., 326 Columbia St., and 5010 38th St., N. E., Seattle, Wash.

CRANNELL, Chas A., (1922), Charles A. Crannell Co., (for mail), 7253 Cottage Grove Ave., and 8336 Paxton Ave., Chicago, Ill.

CRAWFORD, William B., (1921), Mgr. Trap Dept., (for mail), Jas. P. Marsh & Co., 2072 Southport Ave., Chicago, and 1516 N. Mayfield Ave., Cragin Station, Chicago, Ill.

CRIQUI, Albert A.,* (1919), Chief Engr., Htg. and Vtg. Dept., Buffalo Forge Co., 490 Broadway, and (for mail), 250 Blaine Ave., Buffalo, N. Y.

CROFT, Terrell, (1924), Consulting Engr., (for mail), Terrell Croft Engrg. Co., Apartado 275, and Calle 56, Numero 452-A, Merida, Yucatan, Mexico, via New Orleans.

CRONE, Charles E., Jr., (1922), Secy. and Treas., (for mail), Wendt & Crone Co., 1131 N. Wells St., and 1320 N. State St., Chicago, Ill.

CRONE, Thomas E., (1920), Dist. Mgr., Rome Brass Radiator Co., 1 East 42nd St., and (for mail), 236 West 71st St., New York, N. Y.

CRUTCHLEY, Edward, Jr., (1920), Htg. Contractor., (for mail), Edward Crutchley, Jr., 477–83rd St., and 78–89th St., Brooklyn, N. Y.

CULBERT, Warren G., (Associate 1911), Phila. Mgr., Hart & Crouse Co., 3118 Chestnut St., Philadelphia, and 38 Chester Pike, Ridley Park, Pa.

CULLYFORD, Francis S., (1915), Pres. and Mgr., (for mail), Cullyford Plbg. & Htg. Co., 1210 California St., and 517 Josephine St., Denver, Colo.

CUMMING, Robert Worthington, (1928), Engr. and Salesman, Sarco Co., Inc., 183 Madison Ave., New York, and (for mail), 81 Alkamont Ave., Scarsdale, N. Y.

CUMMINGS, Carl H., (Junior 1926; Associate 1927), Mgr., (for mail), Industrial Appliance Co., 250 Stuart St., Boston, and 41 Edgehill Rd., Chestnut Hill, Mass.

CUMMINGS, Charles A., (Junior 1926), (for mail), Capitol Testing Laboratory, U. S. Radiator Corp., 127 Campbell Ave., and 1554 W. Grand Blvd., Detroit, Mich.

CUMMINGS, G. J., (1923), Htg. Mgr. and Dir., (for mail), The Scott Co., 113 Tenth St., and 2001 Hoover Ave., Oakland, Calif.

CUMMINS, George H., (1919), Sales Engr., (for mail), 418 United Artists Bldg., Detroit, Mich.

CURRIER, Charles H., (1919), Vice-Pres. and Gen. Mgr., (for mail), Drying Systems, Inc., 1807 Foster Ave., and 2440 Lake View Ave., Chicago, Ill.

CUTHBERT, Ivan Norman, (1925), (for mail), Cuthbert & Cuthbert, 327 E. Huron St., and 148 Milan Rd., Platt, Ann Arbor, Mich.

CUTLER, Joseph A., (1916), (Council 1917-1926), Mgr., (for mail), Johnson Service Co., 1355 Washington and 649 Hinman Ave., Evanston, Ill.

CUTTER, Edward H., (Associate 1923), Special Distributor, Hoffman Steam Specialties, (for mail), 179 W. Washington St., Chicago, and 912 Douglas Ave., Elgin, Ill.

CUYLER, David H., (1917), Natl. Radiator Co., 334 Forest Ave., Cincinnati, O.

D

DAHLSTROM, Godfrey A., (Associate 1927), Department Mgr., Roberts-Hamilton Co., 713 S. Third St., and (for mail), 2412-28th Ave., S., Minneapolis, Minn.

DAILEY, Jas. A., (Associate 1920), Htg. Contracting, 304 West 14th St., New York, N. Y.

DAILEY, James F., (1924), Pres., Typhoon Fan Co., 345 West 39th St., New York, and (for mail), 25 Wilson Drive, New Rochelle, N. Y.

DALTO, Frank J., (Associate 1926), Plbg. & Htg. Contr., (for mail), 7901–13th Ave., and 1349 74th St., Brooklyn, N. Y.

DALY, John H., (1915), Pres., (for mail), The Daly Co., Distributors, 1635 Blake St., and Denver Athletic Club, Denver, Colo.

DAMBLY, A. Ernest, (Junior 1921; 1924), Asst., (for mail), H. B. Hackett, 505 Chestnut St., Philadelphia, Pa.

DANE, Irving S., (1925), N. E. Mgr., Trane Co., 726 Little Bldg., Boston, and (for mail), 166 George St., Medford, Mass.

DANFORTH, Newman Loring, (1919), Pres., John W. Danforth Co., 72 Ellicott St., Buffalo, N. Y.

DANNIES, F. R., (Associate 1925), Mgr., (for mail), National Radiator Corp., 128 Jefferson St., Milwaukee, and 465 Fourth Ave., Wauwarosa, Wis.

DARTON, Arthur W., (Associate 1925), Htg. Contractor, 314 Fulton St., Union Hill, and (for mail), 331 Brown St., Union Hill, Union City, N. J.

DARTS, John A., (1919), Sales Mgr., (for mail), Kewanee Boiler Co., Inc., 570 Seventh Ave., and 272 Manhattan Ave., New York, N. Y.

DAUCH, Emil O., (1921), Secy. and Treas., (for mail), McCormick Plbg. Supply Co., 1675 Baker St., and (for mail), 81 Montana Ave., W., Detroit, Mich.

DAVIDSON, H. MacD., (Junior 1924; Associate 1926), 3127 Grave St., Berwyn, Ill.

DAVIDSON, L. Clifford, (1927), (for mail), Davidson & Hunger, 1302 Land Title Bldg., and 916 South 49th St., Philadlephia, Pa.

DAVIDSON, Philip L., (Junior 1921; 1924), Territorial Mgr., Carrier Engrg. Corp., Land Title Bldg., Philadelphia, Pa.

DAVIDSON, Ralph Albert, (Junior 1928), Htg. Engr., Petroleum Heat & Power Co., 54 Fifth Ave., New York, N. Y., and (for mail), 76 Prospect Place, Rutherford, N. J.

DAVIES, George W., (1918), Htg. and Vtg. Engr., G. W. Davies & Co., 79 McLaggan St., Dunedin, New Zealand.

DAVIS, A. C., (1920), Asst. Supt., (for mail), The Holland Tunnel, Administration Bldg., Canal and Varick Sts., New York, N. Y., and 73 Preston St., Ridgefield Park, N. J.

DAVIS, Benjamin West, (1927), Plbg. & Htg., 113 Russell St., Ridley Park, Pa.

DAVIS, Bert C., (1904), Pres. and Treas., (for mail), American Warming & Ventilating Co., 317 Pennsylvania Ave., and 603 W. Church St., Elmira, N. Y.

DAVIS, Calvin Russell, (1927), Sales Engr., (for mail), Johnson Service Co., 2328 Locust St., and 7534 Westmoreland Ave., St. Louis, Mo.

DAVIS, Jas. H., (Charter Member), (Board of Governors 1911), 816 S. Michigan Ave., Chicago, Ill.

DAVIS, Joseph, (Associate 1926; 1927), Htg. Engr., and Estimator, W. E. Shaddock, 295 Oak St., and (for mail), 72 W. Northrup Place., Buffalo, N. Y.,

DAVIS, Leo J., (1917), Vice-Pres. and Treas., Davis Bros. Co., 2631 Baker St., and (for mail), 18261 Grayfield Ave., Detroit, Mich.

DAVIS, Otis E., (Associate 1925), Sales Engr., Hoffman Specialty Co., P. O. Box 231, and (for mail), 1523 First Ave., Scottsbluff, Nebr.

DAVIS, Rowland G., (Associate 1921), Sales Engr., Herman Nelson Corp., 1900 Euclid Ave., Cleveland, and (for mail), 887 Nela View Rd., Cleveland Heights, O.

DAY, Vincent Stephen,* (1924), Chief Engr., Carrier-Lyle Corp., 39 Cortlandt St., New York, N. Y.

DECKER, Edward M., (Associate 1917), Salesman, American Radiator Co., 1344 Broadway, Detroit, Mich.

DEEX, Charles J., (1920), Secy., (for mail), Mouat-Vapor Htg. Co., 1246 W. Fourth St., and 4364 Rocky River Drive, Cleveland, O.

DEGAN, James E., (Associate 1916), Pres., (for mail), James E. Degan Co., 622 First St., and 2428 Blaine Ave., Detroit, Mich.

DeHAVEN, I. C., (Associate 1928), Prop., I. C. DeHaven Engrg. Co., (for mail), 708 State Life Bldg., and 48 West 33rd St., Indianapolis, Ind.

DELAND, Charles W., (Junior 1923; 1924), Secy., (for mail), C. W. Johnson, Inc., 211 N. Desplaines St., and 2021 Estes Ave., Chicago, Ill.

DeLONG, Maj. Harry B., (1915), (for mail), H. B. DeLong Co., 409 First Ave., and East 231–24th Ave., Spokane, Wash.

DEMPSEY, Harry P., (1919), Consulting Mech. Engr., (for mail), 34 Delaware Circuit, 232 Delaware Ave., Buffalo, and 394 Pleasant Ave., Hamburg, N. Y.

DeNEILLE, J. Lawrence, (1920), Secy. and Treas., (for mail), Eichler Htg. Co., Railway Exch. Bldg., and 7227 Maryland Ave., St. Louis, Mo.

DENNIS, C. K., (Junior 1923; Associate 1926), Sales Engr., (for mail), Spencer Heaters, 309 O. C. S. Bk. Bldg., and 812 Stolp Ave., Syracuse, N. Y.

DENSON, Walter, (1922), 2916 Olga Place, Jacksonville, Fla.

DePALMA, James Robert, (Junior 1928), Engrg. Draftsman, Thompson-Starrett Co., 245 Hunters Point Ave., Long Island City, and (for mail), 266 Cleveland St., Brooklyn, N. Y.

DERANLEAU, Raymond L., (Junior 1922; 1924), Htg. and Vtg. Engr., (for mail), Jos. F. Pfeiffer Htg. Co., 1140 California St., and 1930 Jasimim St., Denver, Colo.

DeROSA, Angelo, (1925), Htg. Engr., (for mail), DeRosa Htg. Corp., 662 Bleecker St., and 519 Blandina Ave., Utica, N. Y.

DESPAROIS, L. J., (1925), National Radiator Corp., Johnston, Pa.

DEVENDORF, Wm. F., (1910), Prop., (for mail), Wm. F. Devendorf & Co., 70 Exchange St., and 737 East Ave., Rochester, N. Y.

DEWAR, John G., (1920), (for mail), Dewar & Carrington, 153 N. Desplaines St., Chicago, and 797 Pine St., Winnetka, Ill.

DeWOLF, Roger D., (1915), Asst. Supt., (for mail), Elec. Dept., Rochester Gas & Elec. Corp., 89 East Ave., and 330 Barrington St., Rochester, N. Y.

DEXTER, Mac. D., (1924), Pres. and Treas., Dexter Ventilator Co., Columbus, Ga.

DIBBLE, Samuel E.,* (1917), (Presidential Member), (Pres. 1925; Council 1921-1926; 2nd Vice-Pres. 1922; 1st Vice-Pres. 1924), Consulting Engr., and Prof. Htg. and Vtg. Dept., (for mail), Carnegie Institute of Technology, and 514 Hastings St., Pittsburgh, Pa.

DICKEY, Arthur J., (1921), Vice-Pres. and Gen. Mgr., C. A. Dunham Co., Ltd., 1523-41 Davenport Rd., and (for mail), 9 Mossom Place, Toronto, Ont., Can.

DICKINSON, Charles E., (1926), Owner, (for mail), Dickinson Heating Co., 2814 West 55th St., Chicago, and 1210 Central St., Evanston, Ill.

DICKSON, Robert B., (1919), Vice-Pres., in Charge Sales, (for mail), Kewanee Boiler Co., and 409 E. Prospect St., Kewanee, Ill.

DILL, H. O., (Associate 1922), Gen. Sales Mgr., (for mail), Oil City Boiler Works, 501 Fifth Ave., and 243 Mt. Hope Place, New York, N. Y.

DILLMAN, Ernest J., (1921), Engr., (for mail), American Radiator Co., 5961 Lincoln Ave., and 16170 Baylis Ave., Detroit, Mich.

DILLON, H. R., (Associate 1923), Asst. to Gen. Mgr. Sales, (for mail), National Radiator Corp., Johnstown, Pa., and 61 Palmer Ave., Larchmont, N. Y.

DISTEL, Frank, Jr., (1918), Prop., (for mail), Distel Htg. Equipment Co., 125 E. Shiawassee St., and 1011 Genessee St., Lansing, Mich.

DIVER, M. L., (1925), Consulting Engr., 302 Calcasieu Bldg., San Antonio, Tex.

DIX, H. M., (1925), Htg. Engr., Mgr. Htg. Dept., Central Supply Co., Foster Sq., and (for mail), 11 Elmwood St., Worcester, Mass.

DIXON, Arthur G., (1928), Asst. Sales Mgr., Modine Mfg. Co., and (for mail), Apt. 104, 1046 College Ave., Racine, Wis.

DOBBS, C. E., (Associate 1921), Boiler & Radiator Supply Co., 110 Walnut St., Philadelphia, Pa., and (for mail), 72 Berlin Ave., Haddonfield, N. J.

DOBSON, George Gardner, (1922), Mech. Engr., Blower Systems Corp., 362 Plymouth Ave., and (for mail), 166 Harding Rd., Rochester, N. Y.

DODDS, Forrest F., (1920), Mgr., (for mail), American Radiator Co., 1423 Baltimore Ave., and 910 Ward Parkway, Kansas City, Mo.

DOERING, Frank L., (1919), Sales Engr., American Radiator Co., 219 Denver Ave., Lynchburg, Va.

DOHERTY, John A., (1924), Htg. Engr., Richardson & Boynton Co., 260 Fifth Ave., New York, and (for mail), 1834 Schenectady Ave., Brooklyn, N. Y.

DOHERTY, John J., (1921), Owner, (for mail), P. C. Doherty Co., 112 Main St., and 135 Academy St., Poughkeepsie, N. Y.

DOLAN, Edward Michael, (Associate 1927), Editor, (for mail), The Sanitary Age, 14 Irwin Ave., and 10 Ladykirk Ave., Toronto 8, Ont., Can.

DOLAN, Raymond G., (Junior 1922; Associate 1926), 614 W. Grand, Oklahoma City, Okla.

DOLAN, William Henry, Jr., (Junior 1927), Asst. Treas., (for mail), The Jennison Co., 17 Putnam St., and 65 Linden St., Fitchburg, Mass.

DOME, Walter R., (1920), (for mail), Coatesville Boiler Works, Packard Bldg., and 7129 Chew St., Philadelphia, Pa.

DONNELLY, James A.,* (1904), (Treas. 1912-1914), Largent, W. Va.

DONNELLY, Russell, (1923), Sales Engr., (for mail), Nash Engrg. Co., Graybar Bldg., 43rd St. and Lexington Ave., New York, N.Y., and Stamford, Conn.

DONNELLY, Webster C., (Junior 1922), Htg. Engr., Petro-Nassau Corp., 3 Broadway, Lynbrook, L. I.

DONOGHUE, James J., (Associate 1924), Mgr., (for mail), Natl. Radiator Co., 47 West 42nd St., New York, N. Y., and 1957 Boulevard, Jersey City, N. J.

DONOHUE, Edmund S., (Associate 1924), Salesman, (for mail), American Radiator Co., 1344 Broadway, and 50 E. Philadelphia, Detroit, Mich.

DONOVAN, James E., (Junior 1923), Broad St., Port Chester, and (for mail), 618 Forest Ave., Rye, N. Y.

DOODY, C. A., (1924), Asst. to Mgr. Dept. of Research and Field Engrg., Silent Automatic Corp., 255 Meldrum Ave., Detroit, Mich.

DORNHEIM, G. A., (Junior 1906; 1912), (for mail), Thompson-Starrett Co., 245 Hunters Point Ave., Long Island City, and 15 Hamilton Ave., Bronxville, N. Y.

DORSEY, Francis C., (1920), Htg. Plbg. and Elec. Contracting, Francis C. Dorsey, 110 Prospect Ave., Roland Park, Baltimore, Md.

DOUD, Malcolm P., (Associate 1921), (for mail), 6307 W. Girard Ave., Philadelphia, and Rutledge, Pa.

DOUGHERTY, P. J., (1926), Htg. Contracting 208 E. Lomita Ave., Glendale, Calif.

DOUGHTY, Charles John, (1925), Managing Dir. and Treas., (for mail), C. J. Doughty & Co., 30 Brenan Rd., Shanghai, China.

DOUGLASS, Thomas C., (1922), 1237 Cortez Ave., Burlington, Calif.

DOWNE, Edward Reynolds, (1927), Dir., Gas Utilization Dept., (for mail), American Radiator Co., 40 West 40th St., New York, and 31 Howell Ave., Larchmont, N. Y.

DOWNE, Henry S., (1895), Vice-Pres. and European Director, (for mail), American Radiator Co., 149, Boulevard Haussmann, and 5 Rue Verdi, Paris, France.

DOWNES, Nate W., (1917), (Council 1928), Engr., (for mail), School Dist. of Kansas City, 601 Finance Bldg., and 2119 East 68th St., Kansas City, Mo.

DOWNEY, Frank E., (1921), Pres., (for mail), Downey Supply Co., 1217 Clybourn St., and 1188 Prospect Ave., Milwaukee, Wis.

DOWNEY, Paul C., (Junior 1926), Pres. and Treas., (for mail), Downey Heating Co., 256 11th St., and 1914 Cumberland Blvd., Milwaukee, Wis.

DOWNS, Roy N., (Associate 1928), Mgr. Indianapolis Br., (for mail), American Radiator Co., 9 E. Ohio St., and 811 East 42nd St., Indianapolis, Ind.

DOYLE, William J., (1920), Designing Engr., Williamson Heater Co., 4558 Marburg Ave., Oakley, and (for mail), 3766 Hyde Park Ave., Cincinnati, O.

DRAKE, George H., (1919), (for mail), 218 Lexington Ave., and 353 Norwood Ave., Buffalo, N. Y.

DRESEN, William D., (Junior 1926), Estimator, Inland Heating Co., 1120 N. Cicero Ave., and (for mail), 340 N. Pine Ave., Chicago, Ill.

DRIGGS, Leland L., (1918), Htg. Engr., Mack Machine Co. of Penna., 1712 N. Front St., Philadelphia, Pa., and (for mail), 208 E. Clinton Ave., Oaklyn, N. J.

DRINKER, Philip, (1922), Asst. Prof. of Ventilation and Illumination, (for mail), Harvard School of Public Health, 55 Van Dyke St., Boston, and 11 Lowell Rd., Brookline, Mass.

DRISCOLL, William H., (1904), (Presidential Member), (Council 1918-1926; Treas. 1923; 2nd Vice-Pres. 1924; 1st Vice-Pres. 1925; Pres. 1926), Vice-Pres., Thompson-Starett Co., 245 Hunters Point Ave., Long Island City, N.Y., atd 23 Boyd Ave., Jersey City, N. J.

DRUCE, John J., (1922), Vice-Pres. and Mgr., McKelvey & Birch, Ltd., 69 Brock St., and (for mail), 96 Queen's Crescent, Kingston, Ont., Can.

DUBE, Wilbrod, (1925), Consulting Engr., (for mail), Raoul Chenevert, Archt., 20¼ D'Aiguillon St., and 157 Cremazie St., Quebec, Can.

DUBRY, Ernest E., (1924), Asst. Supt. Central Htg., (for mail), Detroit Edison Co., 2000 Second Ave., and 9116 Dexter Blvd., Detroit, Mich.

DUDFIELD, Alvin, (1920), Pres., Dudfield Mfg. Co., 116 W. Kansas St., Liberty, Mo.

DUDLEY, William Lyle, (1922), Vice-Pres., (for mail), Western Blower Co., 1800 Ninth Ave., S., and 2532 Queen Anne Ave., Seattle, Wash.

DUEMLER, Franklin C., (Junior 1926), Sales Engr., Pacific Steel Boiler Corp., 220 South 16th St., Philadelphia, and (for mail), 1032 E. Rittenhouse St., Germantown, Philadelphia, Pa.

DUFF, Kennedy, (1915), Mgr. Eastern Territory, (for mail), Johnson Service Co., 28 West 29th St., New York, N. Y., and 9 Park Ave., Maplewood, N. J.

DUFFIELD, Thomas Jefferson,* (Associate 1927), Executive Secy., (for mail), New York Commission on Ventilation, 370 Seventh Ave., and 400 West 119th St., New York, N. Y.

DUGAN, Thomas M., (1920), Engr., (for mail), National Tube Co., Fourth Ave. and Locust St., and 1308 Freemont, McKeesport, Pa.

DUNCAN, George W., Jr., (1923), Consulting Mech. Engr., U. S. Veterans Hospital, Camp Kearney, and (for mail), 2132 Derby St., Berkeley, Calif.

DUNCAN, John M., (1924), Mech. Engr., Atmospheric Nitrogen Corp., Syracuse, N. Y.

DUNHAM, Clayton A., (1911), Pres., (for mail), C. A. Dunham Co., 450 E. Ohio St., Chicago, and 150 Maple Hill Rd., Glencoe, Ill.

DUNLAP, Ralph L., (1917), Engr., (for mail), J. H. Kitchen & Co., Pioneer Trust Bldg., 1016 Baltimore Ave., and 5533 Holmes St., Kansas City, Mo.

DUNLEVY, Thomas Ross, (1925), Mgr., Anthracite Coal Service, 75 Westminster St., and (for mail), 170 Alabama Ave., Edge Sta., Providence, R. I.

DURAND, William L., (1921), Engr., (for mail), Clark, McMullen & Riley, 101 Park Ave., New York, and 242 Lafayette Ave., Brooklyn, N. Y.

DUSOSSOIT, Edmond A., (1920), Treas., (for mail), Lynch & Woodward, Inc., 320 Dover St., Boston, and 16 Hancock Ave., Newton Centre, Mass.

DWYER, Thomas F., (1923), Mech. Engr., (for mail), Board of Education, Flatbush Ave. and Concord St., Brooklyn, and 282 Cypress Ave., New York, N. Y.

DYER, Orville K., (1919), Mgr. Blower Dept., (for mail), Buffalo Forge Co., 490 Broadway, and 11 Russell Ave., Buffalo, N. Y.

DYER, William Saul, (Associate 1927), Pres., Dyer Heating Co., 408 Graham Ave., Brooklyn, N. Y.

E

EADIE, John G., (1909), Consulting Engr., (for mail), Eadie, Freund & Campbell, 110 West 40th St., New York, N. Y., and 11 Blackburn Rd., Summit, N. J.

EAGAN, Walter H., (1926), Pres., Walter H. Eagan & Co., 1612 Vine St., Philadelphia, Pa.

EAGAR, R. Frank, (1922), Engr., (for mail), 138 Lower Water St., and 44 South Park St., Halifax, N. S.

EAKINS, Walter, (1928), Engr. and Estimator, (for mail), Louis J. Sommer & Son, Inc., 2436 Brown St., and 336 E. Phil Ellena St., Philadelphia, Pa.

EARLY, George David, (Associate 1927), Business Repr., Steam Fitter, Rm. 102 Labor Temple, and 7803 W. Green St. Way, Seattle, Wash.

EASTERBROOKS, Clifton C., (1922), Sales Engr., (for mail), Koithan & Pryor, 39 Cortlandt St., and 2735 Sedgewick Ave., New York, N. Y.

EASTWOOD, Everett Owen, (1921), Prof. Mech. Engrg. (for mail), Univ. of Washington, and 4702 12th Ave., N.E., Seattle, Wash.

EASTWOOD, Harry Fuller, (1925), Vice-Pres., In Charge of Engrg., (for mail), Combustion Specialties Corp., 250 West 54th St., New York, and 157 Franklin Blvd., Merrick, L. I., N. Y.

EATON, Byron K., (Associate 1919; 1920), Gen. Sales Mgr., Winslow Boiler & Engr. Co., 208 S. LaSalle St., Chicago, and (for mail), 522 N. Fifth Ave., La Grange, Ill.

EATON, Phillips, (1927), Salesman, H. B. Smith Co., 640 Main St., Cambridge, Mass., and (for mail), 40 Caldwell St., Woodfords, Me.

EATON, Roy, (Associate 1925), 100 Boylston St., Boston, Mass.

EBERLE, Carl Frederick, (Junior 1926), Owner, (for mail), Eberle's Little Plumber, 121 N. Main St., and Beaver and Clay Sts., Zelienople, Pa.

EBERT, William A., (1920), Engr. and Estimator, A. H. Shafer, 418 St. May St., and (for mail), P. O. Box 1280, San Antonio, Tex.

EBIN, Louis.* (1924), Htg. and Vtg. Engr., (for mail), Phillips-Getschow Co., 421 N. State St., and 3644 Leland Ave., Chicago, Ill.

ECKARDT, C. A. T., (Associate 1924), Engr., the Whitelock Coil Pipe Co., 726 Commercial Trust Bldg., Philadelphia, and (for mail), 456 Irvington Rd., Drexel Park, Pa.

ECKART, Claude H., (1915), Secy., (for mail), Eckart Bros., Inc., 419-23 Eight Ave., N., and 9675-48th St., S. W., Seattle, Wash.

ECKLES, Robert Arthur, (1926), Architectural Engr., (for mail), W. G. Eckles Co., L. S. and T. Bldg., and 501 Winter Ave., New Castle, Pa.

EDDY, William Horace, (Associate 1927), Pres. and Treas., W. H. Eddy Co., 1706-12th St., and (for mail), 802 E. Fifth St., Superior, Wis.

EDGAR, Andrew C., (Charter Member), (Council 1920), Dir., (for mail), Certified Heating Association, Inc., 1202 Locust St., Philadelphia, and Media Rd., Newton Square, Pa.

EDWARDS, Clarence H., (Associate 1924), Prop., R. M. Edwards & Son, 4 N. Central Ave., Canonsburg, Pa.

EDWARDS, Daniel F., (1920), Co-partner, (for mail), D. F. Edwards Htg. Co., 2340 Pine St., St. Louis, Mo., and R. No. 1, Millstadt, Ill.

EDWARDS, Paul A., (1919), Pres., (for mail), G. F. Higgins Co., 606 Wabash Bldg., and 3074 Pinehurst Ave., Pittsburgh, Pa.

EDWARDS, Ralph H., (Associate 1928), Pres., (for mail), Sink & Edwards, 621 E. Ohio St. and 3905 Carrollton Ave., Indianapolis, Ind.

EELLS, Henry B., (1926), Sales Repr., Barnes & Jones, 101 Park Ave., New York, and (for mail), 1049 East 27th St., Brooklyn, N. Y.

EGGLESTON, Lewis W., (1921), Mgr., (for mail), American Radiator Co., 5961 Lincoln Ave., and 201 E. Kirby Ave., Detroit, Mich.

EHRENZELLER, Adolph, (1924), Mgr. Htg. Dept., Walker & Pratt Mfg. Co., 31 Union St., Boston, and 23 Parlevale Rd., W. Roxbury, Mass.

EHRLICH, M. William,* (1916), Branch Mgr., Trane Co., Room 2332 Park Row Bldg., New York, N. Y., and (for mail), 56 Ridge Rd., Lyndhurst, N. J.

EICHER, Hubert C., Dr., (1922), State Director, Bureau of School Bldgs., Dept. of Public Instruction, State Capitol, and (for mail), 103 South St., Harrisburg, Pa.

EICHLER, Alvin, (1919), (for mail), Eichler Htg. Co., 2010 Railway Exch. Bldg., and 6643 Kingsbury Place, St. Louis, Mo.

EISERT, Hermann,* (1920), Consulting Engr., 404 St. Paul Place, and (for mail), 4007 Bateman Ave., Baltimore, Md.

ELLIS, Ernest E., (1922), Secy. and Treas., (for mail), Fred A. Ellis & Son, 840 Center St., and 998 Chatfield St., Winnetka, Ill.

ELLIS, Frederic R., (1913), Sales Engr., Buerke & Co., 24 Union Park St., Boston, and (for mail) 131 Beacon St., Hyde Park, Mass.

ELLIS, Harry W., (Associate 1909; 1923), Pres. and Gen. Mgr., Johnson Service Co., 149 Michigan St., Milwaukee, Wis.

ELLIS, Wilbur H., (Junior 1926; Associate 1927), Htg. and Vtg. Estimator, J. L. Murphy, Inc., 340 East 44th St., New York, and 97 Caryl Ave., Yonkers, N. Y.

ELLISON, J. Huyler, (1919), Pres., Ellison & Co., Inc., 211 West 126th St., New York, and (for mail), 41 Wallace St., Freeport, N. Y.

ELY, F. Ernest, (Associate 1925), Mgr. New York Office, (for mail), Taylor Instrument Co., 31 Union Sq., New York, N. Y., and 54 Early St., Morristown, N. J.

EMERICK, Stanley H., (Junior 1923; Associate 1925), Mech. Engr., (for mail), Weston & Ellington, Archt. and Engrs., 1507 Stroh Bldg., and 1560 Fairview Ave., Detroit, Mich.

EMERSON, Ralph R., (1922), Sales Engr., (for mail), Hoffman Specialty Co., 25 West 45th St., New York, and 660-59th St., Brooklyn, N. Y.

EMERY, William D., (1923), Pres., (for mail), Blest & Emery Co., 784 Coney Island Ave., and 496 Argyle Rd., Brooklyn, N. Y.

EMMERT, Luther D., (1919), Repr., (for mail), Buffalo Forge Co., 562 W. Washington Blvd., Chicago, and 1704 Hinman Ave., Evanston, Ill.

EMSWILER, John E.,* (1917), Prof. Mech. Engrg., (for mail), Univ. of Michigan, 231 Engrg. Bldg., and 1303 Granger Ave., Ann Arbor, Mich.

ENGLE, Alfred, (Associate 1923), Asst. Sales Mgr., Jenkins Bros., 80 White St., and 60 West 190th St., New York, N. Y.

ENGLISH, Alpheus T., (Associate 1926), Dist. Mgr., Columbus Htg. & Vtg. Co., 638 Wabash Bldg., Pittsburgh, Pa.

ENSIGN, Ralph M., (1917), Pres., (for mail), The Ensign Engrg. Co., 35 E. Wacker Drive., and 411 Fullerton Pkwy., Chicago, Ill.

ERICKSON, Harry A., (1917), Bureau of Quality Surveys, Inc., 314 Keyser Bldg., Baltimore, Md.

ERICKSON, Martin E., (Associate 1926), Supt. of Bldgs., Board of Education, and (for mail), 587-66th Ave., West Allis, Wis.

ERON, Lewis John, (1925), Engr., (for mail), Mead Witter Block, 210 Grand Ave., and 931 Gardner St., Wisconsin Rapids, Wis.

ERTMAN, Bernard Rust, (1920), Mgr., A. F. Ertman, 303 N. Main St., and 6 Ertman Block, Herkimer, N. Y.

EVANS, C. A., (1919), 218 Lexington Ave., Buffalo, N. Y.

EVANS, Edwin C., (1919), Dist. Mgr., Reed Air Filter Co., 841 Oliver Bldg., and (for mail), 2953 Zephyr Ave., Corliss Sta., Pittsburgh, Pa.

EVANS, James Howard, (1926), Mgr., (for mail), Howard Evans Engrg. Specialties, 401 Hernando Bldg., and R. F. D. 7, Lexington, Ky.
EVANS, John, (1919), Archt., (for mail), 30 Water St., and 15 Ball Ave., Galt, Ont., Can.
EVANS, William A., (1918), 24 Woodland Rd., Maplewood, N. J.
EVELETH, Charles F.,* (1911), Engr., (for mail), C. W. Colby & Co., 2341 Carnegie Ave., and 2030 East 115th St., Cleveland, O.
EVLETH, Everett B., (Associate 1927), Br. Mgr., (for mail), Minneapolis-Honeywell Regulator Co., 3732 Washington Blvd., and 1258 Moorland Drive, St. Louis, Mo.
EWING, Dell R., (Associate 1928), Dist. Mgr., (for mail), Ruud Mfg. Co., 875 Main St., Buffalo, and 152 S. Harlem Rd., Snyder, N. Y.

F

FABER, Guy Stanley, (1926), Chief Engr., (for mail), Jas. P. Marsh & Co., 2073 Southport Ave., and 4721 N. Kilpatrick Ave., Chicago, Ill.
FALVEY, John D., (1922), Sales Engr., (for mail), Hester-Bradley Co., 4200 Forest Park Blvd., and 6636 Pershing, St. Louis, Mo.
FANSLER, P. E., (Associate 1927), Associate Editor, (for mail), The Heating & Ventilating Magazine, 243 West 39th St., New York, N. Y., and Sound View Drive, E., Stamford, Conn.
FARLEY, J. W., (Associate 1921), Mgr., Farley, Sleeve & Hanger Co., 3748 East 71st St., Cleveland, O.
FARNHAM, Roswell, (1920), Dist. Sales Engr., (for mail), Buffalo Forge Co., 490 Broadway, and 711 W. Delavan Ave., Buffalo, N. Y.
FARRAR, Cecil W., (Associate 1918; 1920), Vice-Pres., (for mail), Excelso Specialty Works., Inc., 65 Clyde Ave., and 429 Norwood Ave., Buffalo, N. Y.
FAULKNER, Dwight H., (1926), Engr., The H. B. Smith Co., 10 East 41st St., New York, and (for mail), 46 Parsons Drive, Hempstead, N. Y.
FAY, Francis C., (1925), Estimator and Engr., (for mail), Raisler Heating Co., 129 Amsterdam Ave., New York, and 9217–54th Ave., Elmhurst, L. I., N. Y.
FEBREY, Ernest J., (1903), Senior Member, (for mail), E. J. Febrey & Co., 616 New York Ave., N.W., and 1610 Riggs Place, N.W., Washington, D. C.
FEEHAN, J. B., (1923), Pres. and Treas., John B. Feehan, Inc., 471 Union St., Lynn, and 82 Sargent St., Winthrop, Mass.
FEHLIG, John B., (1918), Pres., (for mail), Excelsior Htg. Supply Co., 528 Delaware St., and 2927 Brooklyn Ave., Kansas City, Mo.
FELDMAN, Abram M.,* (1903), Consulting Engr., 145 West 45th St., New York, N. Y.
FELS, Arthur B., (1919), Pres., (for mail), The Fels Co., 60 Union St., Portland, and P. O. Box 33, Yarmouth, Me.
FELTWELL, R. H., (1905), Dist. Mgr., D. & T. Mfg. Co., St. Louis, Mo., and (for mail), 1040 S. Frazier Ter., Philadelphia, Pa.
FENNER, Everett M., (Associate 1928), Sales Engr., American Heating Co., 1 College St., New Haven, Conn.
FENNER, Nicholas Paul, (Junior 1927), Dist. Office Mgr., (for mail), Hoffman Specialty Co., 130 N. Wells St., Chicago, and 362 N. York St., Elmhurst, Ill.
FENSTERMAKER, Sidney E., (1909), Pres., (for mail), S. E. Fenstermaker & Co., 821 Hume-Mansur Bldg., and 3102 Washington Blvd., Indianapolis, Ind.
FERGUSON, Ralph R., (Junior 1925), St. Louis Mgr., (for mail), American Blower Corp., 1221 Boatman's Bk. Bldg., and 6235 Southwood Ave., St. Louis, Mo.
FEST, Leon T., (1919), Phila. Mgr., Pierce, Butler & Pierce Mfg. Corp., 31st and Oxford Sts., and (for mail), 6646 North 18th St., Philadelphia, Pa.
FESTORAZZI, A. O., (Junior 1925), Vice-Pres., (for mail), C. P. Lichty Engrg. Co., Inc., 507 North 22nd St., Birmingham, and 407 Government St., Mobile, Ala.
FIEDLER, Harry W., (1923), Chief Engr., (for mail), Burnham Boiler Corp., 420 Lexington Ave., New York, and 19 Archer Ave., White Plains, N. Y.
FIELDING, Howard H., (1904), (Council 1918-1919), Htg. and Vtg. Engr., (for mail), Warren Webster & Co., 1226 California St., and 607 E. Tenth Ave., Denver, Colo.
FILSON, Foster E., (1924), (for mail), 107 Cherry St., Harrisburg, and 19 N. Second St., Wormleysburg, Pa.
FINAN, Edward John, (Associate 1926), Supervising Engr., Bd. of Education, 650 S. Clark St., and (for mail), 7149 Euclid Ave., Chicago, Ill.
FINAN, James J., (1923), Supervising Engr., Board of Education, City of Chicago, 630 S. Clark St., and (for mail), 7149 Euclid Ave., Chicago, Ill.
FIRESTONE, James F.,* (Associate 1925), Chief Engr., (for mail), The Beckwith Co., and 506 Green St., Dowagiac, Mich.
FIRSCHING, Frank J., (1921), Engr., (for mail), Warren Webster & Co., 1005 Empire Bldg., and 6951 Frankstown Ave., Pittsburgh, Pa.
FISHER, Edwin L., (Associate 1928), Plbg. and Htg. Contracting., 3224 N. Third St., Harrisburg, Pa.
FITCH, Walter S., (1926), Construction Engr., (for mail), Dennison Mfg. Co., 300 Howard St., Framingham, and 27 Summit Rd., Wellesley, Mass.
FITZ, Jean Chandler, (1925), Htg. Engr. and Estimator, Louis J. Sommer & Son, 2436 Brown St., and (for mail), 4213 Darien St., Philadelphia, Pa.
FIX, Frederick W., Jr., (Associate 1927), Treas., (for mail), Kellogg-Mackay Co., 1351 West 37th Place, Chicago, and 535 Hinman Ave., Evanston, Ill.
FLEISHER, Walter L.,* (1914), Vice-Pres., (for mail), Cooling & Air Conditioning Corp., 11 West 42nd St., and 129 West 11th St., New York, N. Y.
FLEMING, James P., (1923), Engr., Custodian, (for mail), Board of Education, 1410 N. Rockwell St., and 4035 N. Keystone Ave., Chicago, Ill.
FLEMING, Ralph A., (1926), Member of Firm, Floyd L. Benedict, Inc., 960 College Ave., and (for mail), 137 E. Tompkins St., Columbus, O.
FLEMING, Thomas C., (1919), 5239 North 15th St., Philadelphia, Pa.
FLEMMING, Walter L., (Junior 1928), Mgr., (for mail), W. F. Hirschman Co., 525 Sixth Ave., and 1370 University Ave., New York, N. Y.
FLETCHER, Sarton W., (1923), Sales Engr., (for mail), J. O. Ross Engrg. Co., 30 East 42nd St., New York, and 67 S. Broadway, White Plains, N. Y.
FLETT, Henry R., (Associate 1915; 1915), Mgr., (for mail), Taylor-Forbes Co., Ltd., 1088 King St., W., and 170 Indian Rd., Toronto, Ont., Can.
FLINK, Carl H., (1923), Chief Engr., (for mail), Gas Utilization, American Radiator Co., 40 West 40th St., New York, and 324 First Ave., N. Pelham, N. Y.
FLINT, Coll T., (1919), Sales Mgr., (for mail), H. B. Smith Co., 640 Main St., Cambridge, and 56 Brantwood Rd., Arlington, Mass.
FLORENCE, William E., Jr., (Junior 1924; Associate 1925), Engr., Acme Htg. & Vtg. Co., 13 Hawkins St., Boston, and (for mail), Weston Rd., Reading, Mass.
FOLEY, William J., (Associate 1923), Pres. and Mgr., (for mail), Wm. J. Foley Htg. Service Co., 230–15th St., and 360 Colorado Blvd., Denver, Colo.
FOLLEY, E. B., (1928), Pres. and Gen. Mgr., (for mail), Gaylord & Eitapence Co., 179 Washington St., and 50 Beethoven St., Binghamton, N. Y.
FORFAR, Donald M., (1917), Sales Engr., (for mail), Grinnell Co., 240 Seventh Ave., S., and 4817 Emerson Ave., S., Minneapolis, Minn.

FORGAN, Donald M., (Associate 1923), Mgr., American Radiator, 40 West 40th St., New York, N. Y.
FORGEE, Frederick A., (1919), Consulting Engr., (for mail), 141 East 29th St., New York, N. Y., and Ridgewood, N. J.
FORSBERG, William, (1919), Secy., (for mail), Hopson & Chapin Mfg. Co., 231 State St., New London, and Quaker Hill, Conn.
FOSTER, Charles, (1923), Consulting Engr., (for mail), 512 Sellwood Bldg., and 2831 E. First St., Duluth, Minn.
FOSTER, James M., (Associate 1920), Dist. Mgr., (for mail), Ilg Elec. Vtg. Co., 1421 Syndicate Trust Bldg., and 7021 Lindell Blvd., St. Louis, Mo.
FOSTER, William M., (Associate 1914), Vice-Pres. and Gen. Mgr., (for mail), The Leggett-Doll-Foster Co., 16508 Woodward Ave., Highland Park, and 19 Wellesley Drive, Pleasant Ridge, Mich.
FOUILHOUX, J. Andre, (1915), Archt. and Engr., Raymond Hood, Godley & Fouilhoux, 40 West 40th St., New York, N. Y., and (for mail), Short Hills, N. J.
FOULDS, Powys A. L., (1916), Mech. Engr., (for mail), Hollis French & A. Hubbard, 210 South St., Boston, and 854 N. Shore Rd., Revere, Mass.
FRANK, John M., (Associate 1912; 1918), Vice-Pres., (for mail), Ilg Elec. Vtg. Co., 2850 N. Crawford Ave., Chicago, and 1152 Chatfield Rd., Hubbard Woods, Ill.
FRANK, Olive E.,* (1919), Pres., (for mail), O. E. Frank Heater & Engr. Co., 20 Milburn St., and 296 Norwalk Ave., Buffalo, N. Y.
FRANKEL, Gilbert, (1926), Sales Engr., (for mail), Buffalo Forge Co., 490 Broadway, and 567 Delaware Ave., Buffalo, N. Y.
FRANKLIN, Ralph S., (1919), Pres. and Treas., (for mail), Albert B. Franklin, Inc., 25 Haverhill St., Boston, and 320 Grove St., Melrose, Mass.
FRANZHEIM, Geo. W., (1924), Pres. and Gen. Mgr., Universal Smokeless Boiler Co., Ravenna, O.
FRASER, William G., (1916), Vice-Pres., (for mail), Power Efficiency Corp., 137 Arthur St., and 1515 Amherst St., Buffalo, N. Y.
FREAS, Royal Bruce, (1928), Pres. and Mgr., (for mail), The Thermo Elec. Instrument Co., 1206 S. Grove St., Irvington, and 117 Hillcrest Ave., Leonia, N. J.
FRENCH, Donald E., (1926), Mgr. Htg. Dept., (for mail), York Heating & Ventilating Corp., 16th and Sansom Sts., Philadelphia, and Merion, Pa.
FREYN, Harry L., (Associate 1928), Owner, Freyn Bros., 1028 N. Illi St., Indianapolis, Ind.
FRIEDMAN, Abraham, (1922), Htg. Contractor, Friedman & Kiss, Inc., 769 Third St., New York, and 2529 Erickson St., Elmhurst, L. I., N. Y.
FRIEDMAN, Ferdinand J., (1921), Mech. Engr., (for mail), McDougall, Pease & Friedman, 85 Osborne St., and 670 Sherbrooke St., W., Montreal, Que., Can.
FROST, Robinson V.,* (1921), The Frost Research Laboratory, Inc., 1326 Markley St., Norristown, Pa.
FRUTCHEY, Marcus Peter, Jr., (Junior 1927), Consulting Engr., 59 Grove Ave., Verona, N. J.
FRUTCHY, Asel E., (Junior 1920; 1924), Vice-Pres., (for mail), Frutchy-Barnes Co., 104 W. Second St., and 864 Euclid Ave., Elmira, N. Y.
FRY, J. D., (Junior 1924), Asst. Engr., (for mail), McDougall, Pease & Friedman, 85 Osborne St., Montreal, and 16 Thornhill Ave., Westmount, Que., Can.
FRYER, Frederick G., (1918), Director, Rowntree & Co., Ltd., York, England.
FUKUI, Kunitaro, (1927), Director, (for mail), Fukui & Co., Tokio Kaijo Bldg., Marunouchi, and Shiba, Tokyo, Japan.
FULLER, J. Lansing, (Associate 1916), Dist. Sales Mgr., (for mail), Hart & Crouse Co., 459 York St., and 1745 Chicago Blvd., Detroit, Mich.
FUNCK, Elmer H., (Junior 1926), Sales Engr., Johnson Fan & Blower Co., 1319 W. Lake St., Chicago, and Library Plays, Evanston, Ill.

G

GABY, Frederick A., (1926), Chief Engr., (for mail), Hydro Elec. Power Comm., 190 University Ave., and 480 Spadina Rd., Toronto, Ont., Can.
GALE, Thomas J., (Associate 1920; 1921), Htg. and Piping Engr., Contractors St. Louis Assn., 1795 Railway Exchange Bldg., and (for mail), 2705 S. Kingshighway, St. Louis, Mo.
GALLAHER, A. J., (1926), Pres., (for mail), Gallaher Boiler Co., 508 Star Bldg., and 3943 Cleveland Ave., St. Louis, Mo.
GALLAHER, James Ed., (Junior 1923; Associate 1923; 1927), Engr., Smith, Hinchman & Grylls, Marquette Bldg., Detroit, Mich.
GALLIGAN, Andrew B., (1921), Mgr., (for mail), Galligan Bros., 716 South 51st St., and 5987 Woodbine Ave., Philadelphia, Pa.
GALLIGAN, John H., (1923), Engr., (for mail), Marine Galligan Co., 14 South 20th St., and 1930 South 56th St., Philadelphia, Pa.
GANNON, James E., (1918), Pres. and Treas., (for mail), Gannon & Carey Co., 903 Parade St., and 508 West 11th St., Erie, Pa.
GANT, H. P.,* (1915), (Presidential Member), (Pres. 1923; Council 1918; 1924; 2nd Vice-Pres. 1921; 1st Vice-Pres. 1922), Vice-Pres., (for mail), York Htg. & Vtg. Corp., York Bldg., 16th and Sansom Sts., and Penn Athletic Club, Philadelphia, Pa.
GARDNER, B. F., (1924), Plbg. and Htg. Contr., 322 Myrtle Ave., and (for mail), 277 Carlton Ave., Brooklyn, N. Y.
GARDNER, S. Franklin, (1911), Member of Firm, (for mail), Standard Engrg. Co., 2129 Eye St., N.W., and 3805 Kanawha St., Washington, D. C.
GARDNER, W., Jr., (Associate 1921), Sales Mgr., (for mail), Gardner City Fan Co., 1842 McCormick Bldg., and 7836 Loomis St., Chicago, Ill.
GASSLER, John H., (Junior 1927), Htg. Engr., Crane Co., 738 W. Bay St., and (for mail), P. O. Box 4242, Jacksonville, Fla.
GAST, Charles, (1928), Gen. Supt., (for mail), Manhattan Bronx Power Corp., 116 East 19th St., New York, and 2 Rutland Place, Rockville Center, N. Y.
GAULIN, Richard P., (Junior 1925), 3611 Walnut St., Philadelphia, Pa.
GAUSMAN, Carl E., (1923), G. M. Orr & Co., 816 Second Ave., S., Minneapolis, and 1528 Iglehart Ave., St. Paul, Minn.
GAUVIN, Leon Gough, (1926), Engr., Power Efficiency Corp., 137 Arthur St., and (for mail), 45 E. Delavan Ave., Buffalo, N. Y.
GAWTHROP, Fred H., (1919), Pres. and Treas., (for mail), Gawthrop & Bro. Co., 705 Orange St., and 2211 Shallcross Ave., Wilmington, Del.
GAYLOR, William S., (1919), Htg. and Vtg. Engr., Starrett & Van Vleck, 8 West 40th St., New York, and (for mail), 42 Mayhew Ave., Larchmont, N. Y.
GAYLORD, F. H., (1921), (for mail), Hoffman Specialty Co., Inc., 130 N. Wells St., Chicago, and 362 N. York St., Elmhurst, Ill.
GEIGER, Irvin H., (1923), Registered Professional Engr. and Mfrs. Rep., (for mail), 600 N. Second St., and 240 Maclay St., Harrisburg, Pa.
GEMENY, William J., (1919), Pres., (for mail), W. J. Gemeny Co., 2528 W. Madison St., and 7601 Normal St., Chicago, Ill.
GERRISH, Harry E., (1910), (Council 1919), Partner, (for mail), Morgan-Gerrish Co., 800 LaSalle Ave., and 4534 S. Freemont Ave., Minneapolis, Minn.
GETSCHOW, Geo. M., (1906), Pres. and Treas., (for mail), Phillips-Getschow Co., 421 N. State St., and 4542 Beacon St., Chicago, Ill.
GETSCHOW, Roy M., (1919), Secy., (for mail), Phillips-Getschow Co., 421 N. State St., and 1336 Arthur Ave., Chicago, Ill.

GIBBONS, M. J., Jr., (1914), Secy., (for mail), M. J. Gibbons Supply Co., 601 E. Monument Ave., and 22 Oxford Ave., Dayton.

GIBBS, Edward W., (1919), (for mail), The Smith-Gibbs Co., 11 S. Main St., and 61 President Ave., Providence, R. I.

GIBBS, Frank C., (1921), Gen. Supt., (for mail), National Regulator Co., 2301 Knox Ave., Chicago, and 430 S. Oak Park Ave., Oak Park, Ill.

GIESECKE, F. E.,* (1913), Dir. Engrg. Experiment Sta., Agricultural and Mechanical College of Texas, College Sta., Tex.

GIFFORD, Robert Fulton, (1927), Dist. Repr., Shaw-Perkins Mfg. Co., 89 Broad St., Boston, Mass.

GIFFORD, Robert L., (1908), Pres., Illinois Eng. Co., 21st St. and Racine Ave., Chicago, Ill., and (for mail), 1231 S. El Molino Ave. Pasadena, Calif.

GIGUERE, Geo. H., (1920), Mech. Engr., Smith, Hinchman & Grylls, 800 Marquette Bldg., and (for mail), 13002 Greinef Ave., Detroit, Mich.

GILBERT, Maxwell F., (Associate 1915), Mgr., (for mail), Richardson & Boynton Co., 1308 Arch St., Philadelphia, and 138 Fenbrook Ave., Wyncote, Pa.

GILBOY, John P., (1924), Sales Repr., Products, (for mail), Herman Nelson Co., 810 Scranton Elec. Bldg., and 1725 Olive St., Scranton, Pa.

GILDEA, Thomas Emmett, (1907), 127 Coolidge Ave., Syracuse, N. Y.

GILLETT, Merriman C., (1916), Asst. Sales Mgr., Hoffman Specialty Co., 25 West 45th St., New York, N. Y., and (for mail), 6600 Rising Sun Ave., Philadelphia, Pa.

GILLHAM, Walter E.,* (1917), (Treas. 1926; Council 1924-1926), Consulting Engr., (for mail), 409 Interstate Bldg., and 3427 Bellefontaine, Kansas City, Mo.

GILLING, William F., Jr., (Associate 1919), Asst. Mgr., American Radiator Co., 129 Federal St., Boston, and (for mail), 29 Abbott Rd., Wellesley Hills, Mass.

GILMORE, Frank P., (1923), Sales Engr., (for mail), Peerless Unit Ventilation Co., Room 838, 100 Boylston St., Boston, and 21 Highland Ave., Somerville, Mass.

GILMORE, R. E., (1923), Consulting Engr., Rm. 1619 Monroe Bldg., 104 S. Michigan Ave., and (for mail), 4243 Sheridan Rd., Chicago, Ill.

GIVIN, Albert W., (Associate 1925), Mgr., (for mail), Taylor Forbes Co., Ltd., 1070 Homer St., and 2849-42nd Ave., W., Vancouver, B. C.

GLASSEY, J. Wilbur, (1922), Partner, (for mail), Vapor Engrg. Co., 10 South 18th St., and 7818 Ardleigh St., Chestnut Hill, Philadelphia, Pa.

GLEASON, Gilbert H., (1923), 25 Huntington Ave., Boston, and 43 Clyde St., Newtonville, Mass.

GLORE, Evins Foree,* (Associate 1916), Pres., Evins F. Glore & Son, Inc., Manley St. and Anable Ave., Long Island City, and (for mail), 639 West End Ave., New York, N. Y.

GODFREY, Foskett H., (1921), Pres., (for mail), Steam Appliance Co., 2021 L. C. Smith Bldg., Seattle, and Tacoma, Wash.

GOERG, Bernhard, (1928), Asst. Dir., Institute of Thermal Research, American Radiator Co., 675 Bronx River Rd., Yonkers, and 325 Rich Ave., Mt. Vernon, N. Y.

GOETHEL, Alfred C., (Associate 1926), Pres., (for mail), Alfred C. Goethel Co., 829-31st St., and 140 Wright St., Milwaukee, Wis.

GOLDBERG, Harry M., (Junior 1923), 11 Park Place, and 41 Fifth Ave., New York, N. Y.

GOLDSCHMIDT, Otto E., (1915), Consulting Engr., (for mail), 116 West 39th St., and 12 East 97th St., New York, N. Y.

GOLDSTEIN, A. M., (1923), Managing Owner, (for mail), Federal Htg. Co., 1501 Varnum St., Washington, D. C.

GOMBERS, Henry B., (Associate 1901), Secy., (for mail), Htg. and Piping Contractors Natl. Assn., 50 Union Sq., New York, N. Y., and 160 Halsted St., E. Orange, N. J.

GOMERSALL, William H., (Associate 1921), Sales Engr., (for mail), Sherman Engrg. Co., 254 South 15th St., Philadelphia, and (for mail), 7428 Fayette St., Germantown, Philadelphia, Pa.

GOOD, Macy S., (1921), Mgr., Chicago Territory, (for mail), C. A. Dunham Co., 450 E. Ohio St., and 7021 Clyde Ave., Chicago, Ill.

GOODHUE, Albion Paris, (1928), Sales Repr., The Herman Nelson Corp., 43 Court St., Belfast, Me.

GOODLOE, Alfred M., (1924), Vice-Pres., Midwest Air Filters, Inc., Bradford, Pa.

GOODNOW, Wallace F., (1912), Special Repr., (for mail), Pierce, Butler & Pierce Mfg. Corp., 41 East 42nd St., and 260 West 11th St., New York, N. Y.

GOODRICH, Charles F., (1919), Andrews & Goodrich, Inc., 98 Friend St., Boston, Mass.

GOODWIN, Samuel L., (1924), Consulting Engr., 644 Eighth Ave., New York, N. Y., and (for mail), 247 Madison Ave., Hasbrouck Hgts., N. J.

GORDON, Edward B., Jr., (1908), Chas. L. Pillsbury Co., Capital Natl. Bk. Bldg., St. Paul, and (for mail), 3215 Girard Ave., S., Minneapolis, Minn.

GORDON, Edward G., (1923), Robert Gordon, Inc., 1355 W. Washington Blvd., and (for mail), 6655 Ogalah Ave., Chicago, Ill.

GORMLY, John,* (Charter Member; Honorary Member; Presidential Member), (Pres. 1906; Council 1899; Board of Governors 1900-1903; 1st Vice-Pres. 1904), 1436 Locust St., Norristown, Pa.

GORMLY, P., (1919), Consulting Engr., R. D. No. 5, Norristown, Pa.

GORNSTON, Michael H., (Associate 1923), Engr., Junior High School, P. S. 109, 430 Dumont Ave., and (for mail), 251 Crescent St., Brooklyn, N. Y.

GORTNER, John W., (1919), Htg., Vtg. and Sanitary Plumber, (for mail), A. W. Gortner & Son, 318 Sunbury St., and 42 N. Sixth St., Shamokin, Pa.

GORTON, G. H., (Associate 1924), W. B. Young Supply Co., 208 Delaware St., Kansas City, Mo.

GOSS, Matthew H., (1921), Estimator and Engr., The Brown Co., 1053 Baltimore Ave., W., and (for mail), 1254 E. Grand Blvd., Detroit, Mich.

GOSSETT, Earl J., (1923), Pres., (for mail), Bell & Gossett Co., 3000 S. Wallace St., and 1609 Ridge Ave., Evanston, Ill.

GOTTWALD, C., (Associate 1916), Pres., (for mail), The Ric-Wil Co., 1573 Union Trust Bldg., and 2225 Stillman Rd., Cleveland, O.

GRAHAM, Charles Danne, (Junior 1927), Asst. Chief Engr., (for mail), York Heating & Ventilating Corp., 16th and Sansom Sts., Philadelphia, and 39 W. Athens Ave., Ardmore, Pa.

GRAHAM, William D., (Junior 1923; Associate 1925), Dist. Mgr., (for mail), York Htg. & Vtg. Corp., Rm. 1804, 208 W. Washington St., Chicago, and 2641 Prairie Ave., Evanston, Ill.

GRAHN, Victor F., (1927), Engr., Tenney & Ohmes, 101 Park Ave., New York, N. Y., and (for mail), 120 Greenwood Ave., East Orange, N. J.

GRANT, Albert E., (1928), Pres., (for mail), Grant Home Heater Corp., Grant Accessories Corp., 2 Rector St., and 3305 Broadway, New York, N. Y.

GRASSLER, Edmund, (Associate 1919), Grassler & Gezelschap, (for mail), 214 Third St., and 750 Summit Ave., Milwaukee, Wis.

GRAVES, Clarence C., (Associate 1925), Secy., (for mail), Heating Service Co., 3047 Sheffield Ave., and 4110 N. Kilbourn Ave., Chicago, Ill.

GRAVES, Ralph E., (Associate 1923), Sales Representative, (for mail), Fulton Co., 1014 Holland Bldg., St. Louis, and 8516 Florence Ave., Webster Groves, Mo.

GRAVES, Willard B., (1906), Pres., (for mail), W. B. Graves Htg. Co., 162 N. Desplaines St., Chicago, and 531 Edgewood Place, River Forest, Ill.

GRAY, George A., (1924), Mgr., Br. Sales, (for mail), C. A. Dunham Co., Ltd., 404 Plaza Bldg., and 115 Belmont Ave., Ottawa, Ont., Can.

GRAY, William E., (1922), Sales Engr., Merritt Engrg. and Sales Co., Inc., Lockport, N. Y., and (for mail), 2237 Greenwood St., Harrisburg, Pa.

GREBE, Henry W., (1919), Pres., (for mail), Central Asbestos & Magnesia Co., 214 W. Grand Ave., and 2650 Wilson Ave., Chicago, Ill.

GREEN, John E., (Associate 1926), Owner and Prop., 11820 Brush St., and 2411 Glynn Court, Detroit, Mich.

GREEN, William C., (1906), Br. Mgr., (for mail), Warren Webster & Co., 919 Provident Bk. Bldg., and 244 Erkenbrecher Ave., Cincinnati, O.

GREENE, Walter C., (1921), Mgr., (for mail), W. C. Greene Co., 1629 Union Trust Bldg., Cleveland, and 2400 Demington Drive, Cleveland Hgts., O.

GRIER, William, (1908), P. O. Box 75, Cincinnati, O.

GRIFFIN, Byron Henry, (1928), Sales Engr., Heggie Simplex Boiler Co., 457 Fifth Ave., New York, and (for mail), 2150 Bedford Ave., Brooklyn, N. Y.

GRIFFIN, Frank A., Jr., (1917), Sales Engr., (for mail), Kellogg-Mackay Co., 2030 Walnut St., and 3930 S. Benton St., Kansas City, Mo.

GRIFFIN, John Joseph, (1928), Sales Repr., Hoffman Specialty Co., 2807 Windsor Ave., Baltimore, Md.

GRIFFIN, Porter C., (1923), Supt. of Plbg. and Htg., Hutton Bros. Co., 9 Union St., and (for mail), 151 Oak St., Winsted, Conn.

GRILL, Guido E., (Junior 1922), Designer, (for mail), Clark, McMullen & Riley, 101 Park Ave., New York, and 90 Alter Ave., Dongan Hills, S. I., New York.

GRONBERG, C. E., (Associate 1928), Dist. Mgr., B. F. Sturtevant Co., (for mail), 1101 New City Trust Bldg., and 5636 Guilford St., Indianapolis, Ind.

GROOM, Stanley L., (1920), Managing Director, Buffalo Forge Co., Ltd., 24 Buckingham Gate, and (for mail), Homstead Thrale Rd., Streatham, London, Eng.

GROSS, R. A., (1923), Ben Rigby, Inc., 604 W. Lake St., Chicago, and (for mail), 527 N. Washington St., Park Ridge, Ill.

GROSSMAN, Harry Edward, (Junior 1927), Engrg. Dept., Burnham Corp., Graybar Bldg., 420 Lexington Ave., New York, and (for mail), 16 Neperan Rd., Tarrytown, N. Y.

GROSSMAN, Howard M., (1922), Dist. Sales Mgr., Burnham Boiler Corp., 701 Griest Bldg., and (for mail), 634 Race Ave., Lancaster, Pa.

GROSVOLD, Fred E., (1917), Plbg. and Htg., 411 Grand Ave., E., and (for mail), 603 Main St., Eau Claire, Wis.

GROTZ, Arthur B., (1921), Treas., Patterson-Kelly Co., 101 Park Ave., New York, and (for mail), 59 Old Orchard Lane, Scarsdale, N. Y.

GUEST, Peyton L., (1921), Pres., Smith & Guest, 19 Houston St., and (for mail), 247 McLinden St., Atlanta, Ga.

GUNTHER, Felix A., (1925), Sales Engr., (for mail), Direct Control Valve Co., 1007 Diamond Bk. Bldg., and P. O. Box 137, R. F. D. No. 9, South Hills Branch, Pittsburgh, Pa.

H

HAAS, Samuel L., (1923), Pres. and Treas., (for mail), Advance Htg. Co., 117 N. Desplaines St., and 1513 Fargo Ave., Chicago, Ill.

HAAS, William, (1915), Pres. and Treas., (for mail), The William Haas Co., 429 E. Third St., and 1632 S. Wayne Ave., Dayton, O.

HACKETT, Charles P., (Associate 1921), Partner, Vessey-Hackett Sales Co., 2401 Chestnut St., Philadelphia, and (for mail), 56 W. Eagle Rd., Upper Darby, Pa.

HACKETT, H. Berkeley, (1921), Consulting Engr., (for mail), Public Ledger Bldg., and Lenox Apts., 13th and Spruce Sts., Philadelphia, Pa.

HACKNEY, Henry, (Associate 1919), Contractor and Engr., (for mail), 34 W. Fifth St., and 1514 E. Seventh St., Charlotte, N. C.

HADDOCK, Isaac T., (Associate 1926), Vice-Pres., (for mail), Cambridge Gas Light Co., 719 Massachusetts Ave., Cambridge, and 133 Barnard Ave., Watertown, Mass.

HADEN, George N., (Junior 1922), Director, (for mail), G. N. Haden & Son, and Owens Cottage, Hilperton, Trowbridge, Eng.

HADEN, William N., (1902), Managing Director, (for mail), G. N. Haden & Sons, Ltd., Silver St., and Homefield House, Trowbridge, Eng.

HADESTY, Alfred L., Jr., (1921), 130 E. Broad St., Tamaqua, Pa.

HAGAN, William Vincent, (Junior 1926), Secy., V. J. Hagan Co., 508 Pearl St., and Metz Apt. 303, Sioux City, Ia.

HAGEDON, Charles H., (1919), Secy. and Treas., S. E. Fenstermaker & Co., 821 Hume Mansur Bldg., and 4156 Broadway, Indianapolis, Ind.

HAILEY, Syd Houston, (1925), Asst. Engr., N. C. & St. L. Ry., 924 Broadway, and (for mail), 3737 Harding Rd., Nashville, Tenn.

HAINES, John J., (1915), Vice-Pres. and Secy., (for mail), The Haines Co., 1933 W. Lake St., Chicago, and 623-17th Ave., Maywood, Ill.

HALE, John F.,* (1902), (Presidential Member), (Pres. 1913; Board of Governors 1908, 1910; 1st Vice-Pres. 1912; Council 1913), Dist. Repr., (for mail), Aerofin Corp., Rm. 1531, Burnham Bldg., Chicago, and 408 S. Brainard Ave., LaGrange, Ill.

HALEY, Harry S.,* (1914), Consulting Engr., (for mail), Leland & Haley, 58 Sutter St., and 735 21st Ave., San Francisco, Calif.

HALL, Cortice H., (1927), Chief Engr., Domestic Stoker Co., 815 East 139th St., New York, N. Y., and (for mail), 250 Hamilton Ave., Glen Rock, N. J.

HALL, Thomas, (Associate 1928), Combustion Engr., Automatic Heat. Corp., 3929 Broadway, and (for mail), Kansas City Club, Kansas City, Mo.

HALLETT, Edwin S.,* (1918), (Council 1921; 1923), Chief Engr., (for mail), Board of Education, Board of Education Bldg., and 5156 Cabanne Ave., St. Louis, Mo.

HALLEY, Wilson H., (Junior 1923; 1925), Engr., (for mail), Langenberg Mfg. Co., 4519 N. Euclid Ave., and 6134 W. Park Ave., St. Louis, Mo.

HALLIDAY, Leo, (Associate 1926), Vice-Pres. and Gen. Mgr., (for mail), Newport Boiler Co., Rm. 800, 529 S. Franklin St., and 7242 E. End Ave., Chicago, Ill.

HAMJY, Paul W., (1924), Owner, (for mail), 611 Mohawk St., and 612 Steele Place, Utica, N. Y.

HAMLIN, Harry A., (Associate 1916), Detroit Mgr., (for mail), Johnson Service Co., 427 Brainard St., Detroit, and 120 Winona Ave., Highland Park, Mich.

HANCHETT, James H., (Associate 1926), Mgr., Minneapolis Office, (for mail), The Trane Co., 923 Nicollett Ave., and 1622 West 31st St., Minneapolis, Minn.

HANCOCK, James Reynolds, (Junior 1926), Asst. Mech. Engr., D. X. Murphy & Bro., 714 Louisville Trust Bldg., Louisville, Ky., and (for mail), 131 W. Chestnut St., Jeffersonville, Ind.

HANKIN, Richard, (1898), Vice-Pres., John Hankin & Bros., 228 Cherry St., New York, N. Y., and (for mail), 279 Main Ave., Passaic, N. J.

HANLEY, John H., Jr., (1923), Vice-Pres. and Chief Engr., Reed Engrg. Co., 50 Church St., New York, and (for mail), 1718 East 26th St., Brooklyn, N. Y.

HANSEN, Charles C., (1928), Engr., Pierce, Butler & Pierce Mfg. Co., 41 East 42nd St., New York, N. Y., and (for mail), 428 Prospect St., South Orange, N. J.

HANSON, E. W., (1922), Engr. and Estimator, (for mail), W. N. Sauer Co., 806 Chestnut St., and 919 Eldora Place, Pittsburgh, Pa.

HARBISON, Earl J., (Associate 1924), Mgr., J. E. Harbison, Plbg. and Htg. Contracting, 213 Union St., and (for mail), 1053 Brierwood Blvd., Schenectady, N. Y.

HARBULA, M. G.,* (1921), Consulting Engrs., Air Conditioning Specialists, (for mail), 1564 Broadway, New York, and 3520 Brewster Ave., Flushing, L. I., N. Y.

HARDING, Louis A.,* (1911), (2nd Vice-Pres., 1928), (Council 1922; 1924), Pres., (for mail), L. A. Harding Construction Co., 1335 Main St., and 85 Cleveland Ave., Buffalo, N. Y.

HARDING, Romie M., (1928), Htg. and Vtg. Designer, L. J. Wing Mfg. Co., 154 West 14th St., New York, N. Y., and (for mail), 151 Bloomfield Ave., Passaic, N. J.

HARE, Edgar S., (1920), Pres., (for mail), William Hare's Sons Co., 46–14th St., Wheeling, W. Va., and W. Alexander, Pa.

HARMS, Wm. T.,* (1917), Htg. Contractor, 1173 Clark Ave., Detroit, Mich.

HARPER, Samuel H., (Associate 1927), Prop., (for mail), Heating Equipment Co., 1343 Oliver Bldg., Pittsburgh, and 223 Dalzell Ave., Ben Avon, Pittsburgh, Pa.

HARRIGAN, Edward M., (1915), Gen. Mgr., (for mail), Harrigan & Reid Co., 1365 Baker St., and 7450 LaSalle Blvd., Detroit, Mich.

HARRINGTON, Charles (1923), 160 Grenadier Rd., Toronto, Ont., Can.

HARRIS, Henry W., (Associate 1924), Salesman, J. R. Brockman Mfg. Co., 617 N. Second St., and 4296 Washington Blvd., St. Louis, Mo.

HARRIS, Jesse B., (1918), Partner, (for mail), Rose & Harris, Engrs., 15th and Oak Grove Sts., and 3620 Colfax Ave. S., Minneapolis, Minn.

HARRISON, Burt S., (1918), Chief Engr., Nichols Products Corp., 33 West 42nd St., New York, and (for mail), 148 Clinton St., Brooklyn, N. Y.

HARRISON, James M., (1919), Pres., (for mail), J. M. Harrison, Inc., Guarantee Title Bldg., and 11209 Lake Ave., Cleveland, O.

HART, Harry M., (1912), (Presidential Member), (Pres. 1916; Council 1914; 1917; 1st Vice-Pres. 1915), Pres., (for mail), L. H. Prentice Co., 1048-50 W. Van Buren St., and 5409 Winthrop Ave., Chicago, Ill.

HART, Thomas Henry, (Junior 1927), Htg. and Vtg. Engr., Research Dept., Buckeye Incubator Co., and (for mail), 1827 Stratford Place, Springfield, O.

HARTER, Baxter B., (Junior 1926), Htg. Engr., (for mail), Warren Webster & Co., 549 W. Washington Blvd., and 3904 N. Lincoln St., Chicago, Ill.

HARTMAN, Frank E.,* (1924), Chief Chemist, U. S. Ozone Co., 500 N. Dearborn St., and 6435 N. Richmond St., Chicago, Ill.

HARTMAN, John Milton, (1927), Testing Engr., (for mail), Kewanee Boiler Co., and 719 Henry St., Kewanee, Ill.

HARTPENCE, Charles C., (1923), Htg. and Vtg. Engr., (for mail), P. O. Box 337, and 722 Benking Blvd., Columbus, Ga.

HARTWELL, Joseph C., (1922), Dept. Mgr. and Engr., (for mail), Grinnell Co., Inc., 260 W. Exchange St., and 16 Freeman Parkway, Providence, R. I.

HARVEY, Alexander D., (Junior 1925), Asst. to Sales Mgr., (for mail), Nash Engrg. Co., S. Norwalk, and New Canaan, Conn.

HARVEY, Lyle C., (1928), Sales Promotion Mgr., Bryant Heater & Mfg. Co., 17825 St. Clair Ave., Cleveland, O.

HASEY, Charles E., (1919), C. W. Hasey Co., (for mail), 726 Fourth St., S., and 2613 Third Ave., S., Minneapolis, Minn.

HASKELL, Benj. E., (1925), Engr., Arthur B. Fels, 42 Union St., Portland, and (for mail), 539 Brighton Ave., Woodfords, Me.

HASKINS, A. L., (Associate 1927), Mgr., American Radiator Co., 253 East Ave., Rochester, and (for mail), 400 Laurelton Rd., Irondequoit, N. Y.

HATTIS, Robert E., (1926), Consulting Mech. and Elec. Engr., 6 N. Michigan Ave., Chicago, Ill.

HAUSS, Charles F., (1922), Special Representive for Far East, (for mail), American Radiator Co., 4 Yuen Ming Yuen Rd., and 77 Avenue du Roi Albert, Shanghai, China.

HAWES, Herbert R., (1926), Treas., Edwin Hawes Co., 806 Main St., and (for mail), 22 Elmwood St., Worcester, Mass.

HAYES, James J., (1920), Sales Engr., (for mail), Stannard Power Equipment Co., 926 Monadnock Block, and 7443 Jeffery Ave., Chicago, Ill.

HAYES, Joseph G., (1908), Mgr. and Engr., (for mail), Hayes Bros., Inc., 236 W. Vermont St., and 2849 N. Capitol Ave., Indianapolis, Ind.

HAYNES, Charles V., (1917), (Council 1926), Vice-Pres. and Gen. Sales Mgr., Hoffman Specialty Co., 25 West 45th St., New York, N. Y., and (for mail), 115 Llanfair Rd., Ardmore, Philadelphia, Pa.

HAYWARD, Ralph B., (1909), Pres., (for mail), R. B. Hayward Co., 1714 Sheffield Ave., Chicago, and 201 S. Stone Ave., La Grange, Ill.

HEAGERTY, William H., (Associate 1923), Vice-Pres. and Gen. Mgr., Oil City Boiler Works, Oil City, Pa.

HEAGLER, John M., (1922), Dist. Mgr., (for mail), American Foundry & Furnace Co., 508 Guardian Life Bldg., and 1646 Iglehart, St. Paul, Minn.

HEATH, Samuel C., (Associate 1928), Br. Mgr., U. S. Radiator Corp., 1248 First Ave., S., and (for mail), 2345 31st Ave., S., Seattle, Wash.

HEATH, Frederick R., (1913), Sales Engr., E. B. Badger & Sons Co., 75 Pitts St., Boston, and (for mail), 89 Trowbridge St., Cambridge, Mass.

HEATHERTON, James M., (Associate 1904), Publisher, (for mail), Plumbers Trade Journal Publishing Co., 239 West 30th St., New York, and 395 Clinton Ave., Brooklyn, N. Y.

HECK, George L., Jr., (Associate 1921), Sales Engr., (for mail), Garden City Fan Co., 1842 McCormick Bldg., and 7522 Cornell Ave., Chicago, Ill.

HECKEL, Edmund P., (1918), Vice-Pres., (for mail), Carrier Engrg. Corp., 1032 Burnham Bldg., Chicago, and 314 Cuttriss Place, Park Ridge, Ill.

HEDGES, H. Berkley,* (1919), Sales Mgr., (for mail), York Htg. & Vtg. Corp., 149 Broadway, New York, N. Y., and 1021 Park Lane, Plainfield, N. J.

HEDLEY, Park S., (1923), Mfr's. Agent, (for mail), 374 Delaware Ave., Buffalo, and 31 Westgate Rd., Kenmore, N. Y.

HEEBNER, Walter M., (1922), Sales Engr., Warren Webster & Co., 15 West 34th St., New York, N. Y., and (for mail), 362 Highwood St., Bogota, N. J.

HEIDENREICH, George, (1928), Sales Engr., C. A. Dunham Co., 506 Board of Trade Bldg., Indianapolis, Ind.

HEILES, F. C., (1914; 1920), Perry West Consulting Engr., (for mail), 13 Central Ave., Newark, and 154 Chestnut St., Union, N. J.

HEILMAN, Russell H.,* (1923), Sr. Industrial Fellow, (for mail), Mellon Institute, and 7108 Willard St., Pittsburgh, Pa.

HEINLE, Earl L., (1920), Secy. and Treas., The Kain-Petersen-Heinle Co., 437 E. Tenth St., Cleveland, and (for mail), 2176 Edgewood Rd., Cleveland Heights, O.

HELBURN, I. B., (Junior 1927), Engrg. Dept., (for mail), Reed Air Filter Co., 215 Central Ave., and 1440 S. Fourth St., Louisville, Ky.

HELLERMAN, Harry H., (1902), Pres., (for mail), Treas., The Penn Engrg. Co., 312 Cherry St., and 49th St. and Monument Ave., Philadelphia, Pa.

HELPHINGSTEIN, Otto, (1919), Br. Mgr., (for mail), Cullyford Plbg. & Htg. Co., 119 W. Sixth St., and Amarillo Inn, Amarillo, Tex.

HELSTROM, Herman G., (1928), Salesman, Kewanee Boiler Co., 708 Builders Exchange, Minneapolis, Minn.

HELWIG, Gunther Albert, (1927), Prop., National Htg. & Vtg. Co., 920 Cass Ave., and 4217 Athlone Ave., St. Louis, Mo.

HEMINGWAY, W. S., (1906), Htg. and Vtg. Engr., (for mail), Rm. 519, J. D. Speckels Bldg., and 3213 Mt. View Drive, San Diego, Calif.

HENION, Hudson D., (Associate 1923), Sales Mgr., (for mail), C. A. Dunham Co., Ltd., 1523 Davenport Rd., and 45 Ridge Drive, Toronto, Ont., Can.

HENNINGS, William A., (1926), Htg. Engr., Schmidt, Garden & Erickson, Archts., 104 S. Michigan Ave., and (for mail), 1445 Summerdale Ave., Chicago, Ill.

HENRICH, George A., (1914), Pres., (for mail), Geo. A. Henrich Co., 702 N. Wells St., and 548 Fullerton Parkway, Chicago, Ill.

HENRICI, Hermann C., (1925), Pres., Henrici Lowry Engrg. Co., 508 Huntzinger Bldg., 110 Tenth St., and (for mail), 430 West 58th St., Kansas City, Mo.

HEPBURN, George V., (Associate 1926), Sales Engr., (for mail), Herman Nelson Corp., Builders and Traders Exch., and 840 Pinecrest, E., Grand Rapids, Mich.

HERBACZEK, Edward, (Junior 1925), 4905 N. Whipple St., Apt. 1-B, Chicago, Ill.

HERENDEEN, Frederick W., (1920), Secy., (for mail), The Natl. Boiler & Radiator Mfrs. Assn., 29 Seneca St., and 815 S. Main St., Geneva, N. Y.

HERLIHY, George F., (1922), Vice-Pres., (for mail), J. J. Herlihy, Inc., 810 W. Congress St., and 10836 Forest Ave., Chicago, Ill.

HERLIHY, Jermiah J., (1914), Pres., (for mail), J. J. Herlihy, Inc., 810 W. Congress St., and 3634 N. Keeler Ave., Chicago, Ill.

HERMAN, Harry H., (Junior 1925), Chief Engr., (for mail), Warren Webster Co., 1226 California St., and 612 Milwaukee St., Denver, Colo.

HEROLD, Chas. W., (Associate 1928), Herald Plbg. & Htg. Co., (for mail), 1315 East 26th St., and 2600 Pasco, Kansas City, Mo.

HERRICK, Daniel A., (1923), Factory Mgr., (for mail), Julian d'Este Co., 2 Spice St., Charlestown, and 27 Agassiz St., Cambridge, Mass.

HERRING, Edgar, (1919), Managing Director, (for mail), J. Jeffreys & Co., Ltd., Barron's Place Waterloo Rd., London, S.E., and "Kenia," Keowick Rd., Putney, London, S.W., 15, Eng.

HERSH, G. Willis, (1917), Gen. Mgr., Hersh Bros. Co., 2510 Chew St., Allentown, Pa.

HERSKE, Arthur R., (1926), Mgr., Heating & Piping Contractors Assn., 408 Chester Twelfth Bldg., and 17010 Kenyon Rd., Cleveland, O.

HERTZ, H. Porter, (1924), Engr., (for mail), Routledge & Hertz, Archts., 303 State Exch. Bk., and 314–12th Ave., Hutchinson, Kan.

HERTZLER, John R., (Junior 1928), Student Engr., (for mail), York Ice Mchy. Corp., Yorkco Club, York and 627 N. Duke St., Lancaster, Pa.

HESS, Horace L., (1924), Salesman, H. B. Smith Co., 49th and Grays Ave., W. Philadelphia, and (for mail), 214 Nedro Ave., Olney, Philadelphia, Pa.

HESTER, Thomas J., (1919), Vice-Pres. and Treas., (for mail), Hester, Bradley Co., 4200 Forest Park Blvd., and 67 Aberdeen Place, St. Louis, Mo.

HETHERINGTON, Edward T., (1919), Owner, (for mail), Hetherington Bridge Grate Co., 1709 Sansom St., and 3311 North 16th St., Philadelphia, Pa.

HETTINGER, Henry, (Associate 1927), Chief Engr., (for mail), Metropolitan Life Insurance Co., Bldg., 11 Court Sq., Long Island City, and 40 Rose Ave., Floral Park, N. Y.

HEYDON, Charles G., (Associate 1923), Sales Engr., (for mail), Wright-Austin Co., 315 Woodbridge St., W., and 2681 Nebraska St., Detroit, Mich.

HEYMSFIELD, Herbert R., (Associate 1926), 673 Wales Ave., Bronx, N. Y.

HIBBS, Frank C., (1917), Htg. Engr., The H. B. Smith Co., 49th and Grays Ave., and (for mail), 846 North 65th St., Philadelphia, Pa.

HIERS, Charles R., (Junior 1927), Sales Engr., U. S. Radiator Corp., 101 Park Ave., New York, and (for mail), 81 Fletcher Ave., Mt. Vernon, N. Y.

HIGGINS, Dan T., (1928), Htg. Engr., (for mail), McCarthy-Crandall, Inc., 529 S. Cascade Ave., and 738 E. Platte Ave., Colorado Springs, Colo.

HIGGINS, John M., (1922), Salesman, H. B. Smith Co., 640 Main St., Cambridge 39, and (for mail), 28 Monmouth Ave., W. Medford, Mass.

HIGGINS, Thomas J., (Junior 1923), Vice-Pres. and Mgr., Ross Engrg. Co. of Can., Ltd., New Birks Bldg., Montreal, and 478 Victoria Ave., Westmont, P. Q., Can.

HILL, E. G. T., (1922), Htg. and Vtg. Engr., E. G. Hill & Co., 20 Vermont Crescent, Newland Hill, E. Yorke, Eng.

HILL, E. Vernon,* (Associate 1912; 1914) (Presidential Member), (Pres. 1920; Council 1915; 1917; 1921; 2nd Vice-Pres. 1918; 1st Vice-Pres. 1919), Pres., (for mail), E. Vernon Hill Co., 121 N. Clark St., and 4415 Hazel Ave., Chicago, Ill.

HILL, Newell J., (1916), Consulting Engr., (for mail), 708 Architects Bldg., and 19567 Stratford Drive, Detroit, Mich.

HILLIARD, Charles Ernest, (Junior 1927), Htg. and Vtg. Engr., (for mail), 27 B St., South Boston, and 13 Weir St., Auburndale, Mass.

HILLMAN, R. Ward, (1919), Asst. Vice-Pres., (for mail), U. S. Radiator Corp., 133 E. Grand River Ave., and Pleasant Ridge, Detroit, Mich.

HILLS, Arthur H., (1924), Htg. Engr., C. A. Dunham Co., (for mail), 101 Park Ave., New York, and 20 Rochelle Ter., Mt. Vernon, N. Y.

HINCHMAN, E. G., (1923), Secy., (for mail), E. G. Hinchman Co., 1263 Atlantic Ave., and 547 Eastern Parkway, Brooklyn, N. Y.

HINKLE, Edwin C., (1911), Pres. Atlantic Htg. & Engrg. Co., Second Natl. Bk. Bldg., and (for mail), 170 Franklin Ave., Hempstead, N.Y.

HINRICHSEN, Arthur F., (1928), Vice-Pres., (for mail), Reed Engrg. Co., 50 Church St., New York, N. Y., and Mountain Lakes, N. J.

HIRES, J. Edgar, (1927), Pres., Hires, Castner & Harris, Inc., 1110 Land Title Bldg., Philadelphia, and (for mail), 107 Linwood Ave., Ardmore, Pa.

HIRST, James Noble, (Junior 1927), Chief Draftsman, (for mail), York Htg. & Vtg. Corp., 16th and Sansom Sts., and 2913 Popular St., Philadelphia, Pa.

HITCHCOCK, Frederick P., (1917), Sales Repr., Herman Nelson Corp., (for mail), 309 Lathrop Bldg., and 4938 Forest Ave., Kansas City, Mo.

HOBBS. J. Clarence, (1920), Supt. of Power, Diamond Alkali Co., and (for mail), 60 Wood St., Painesville, O.

HOBEN, Robert J., (1919), Plbg. and Htg. Contractor, (for mail), 258 S. Van Pelt St., and 5102 Spruce St., Philadelphia, Pa.

HOCHULI, Henry W., (1925), Sales Engr., National Radiator Co., 47 West 42nd St., New York, N. Y., and (for mail), 113 Chester Ave., Bloomfield, N. J.

HODGDON, Harry A., (1919), Htg. and Vtg. Engr., Stone-Underhill Htg. & Vtg. Co., 171 Harrison Ave., Boston, and (for mail), 153 Norfolk St., Wollaston, Mass.

HOERSTING, Frank J., (1921), Pres., (for mail), Hoersting & Holtmann, 1133 W. Third St., and 2045 Philadelphia Drive, Dayton, O.

HOFFMAN, Charles F., (Junior 1925), Sales Engr., (for mail), International Heater Co., 1114 Dime Savings Bk. Bldg., and 80 W. Euclid Ave., Detroit, Mich.

HOFFMAN, Charles S., (1924), Vice-Pres., (for mail), 576 Greenwich St., New York, N. Y., and 19 Belvidere Place, Montclair, N. J.

HOFFMAN, George D.,* (1906), P. O. Box 438, Pasadena, Calif.

HOFFMAN, James D.,* (1903), (Presidential Member), 1st Vice-Pres. 1908; Pres. 1910; Board of Governors 1911, 1912), Prof. of Practical Mechanics, Head of Dept., Director of Practical Mech. Lab., (for mail), Purdue University, and 323 University St., W. Lafayette, Ind.

HOFT, Paul J., (Associate 1924; 1925), Prop., Plbg. and Htg. Contractor, (for mail), 245 S. Eighth St., and 1119 Wyoming Ave., Philadelphia, Pa.

HOGAN, Edward L., (1911), Consulting Engr., (for mail), American Blower Co., 6000 Russell St., Detroit, Mich.

HOIER, William V., (1917), Owner, (for mail), Wm. V. Hoier Co., 701 Wells St., and 5960 Kenmore Ave., Chicago, Ill.

HOLBROOK, Frank M., (1923), Power and Htg. Engr., Congoleum-Nairn, Inc., Kearny and 84 Park St., Montclair, N. J.

HOLMBERG, John A., (1924), Mgr., (for mail), The Holmberg Steam Trap Co., 122 E. Lincoln, and 603 N. Second St., Lindsborg, Kans.

HOLMES, Joseph, (1921), Htg. Engr., 1902 Freeman St., Toledo, O.

HOLTON, John H., (1927), Dir. of Research, (for mail), York Htg. & Vtg. Corp., Bridgeport, and 1949 W. Main St., Norristown, Pa.

HONIBALL, Charles R.,* (1911), Pres., Charles R. Honiball Co., 156 Boundary St., Liverpool, Eng.

HOOK, C. Howard, (1915), 6949 Thomas Blvd., Pittsburgh, Pa.

HOOK, Maurice G., (1919), Mgr., (for mail), C. A. Dunham Co., 101 Park Ave., New York, and 11 Henry St., Tuckahoe, N. Y.

HOOVER, H. Earl, (Associate 1922), Vice-Pres., The Hoover Co., 1407 Railway Exch., Chicago, and 1801 Green Bay Rd., Glencoe, Ill.

HOPKIN, William E., (1919), Pres. and Treas., (for mail), Chas. E. Hopkin Co., 107 Bethlehem Pike, and 514 Wyndmoor Ave., Chestnut Hill, Philadelphia, Pa.

HOPSON, William T., (1915), Hopson & Chapin Mfg. Co., New London, Conn.

HORNUNG, John C., (1914), Engr., (for mail), 343 S. Dearborn St., Chicago, and 854 Bluff St., Glencoe, Ill.

HORTON, Homer F., (1925), Sales Repr., (for mail), National Regulator Co., 2301 Knox Ave., Chicago, and 343 Green Bay Rd., Glencoe, Ill.

HOSTERMAN, Charles O., (1924), Supt., The McMurrer Co., 303 Congress St., Boston, and (for mail), 25 Bales Rd., Dorchester, Mass.

HOTCHKISS, Charles H. B., (1927), Asst. Prof. of Htg. and Vtg., (for mail), Purdue University, and 1006 South 11th St., Lafayette, Ind.

HOUGHTEN, Ferry C.,* (1921), (Secy. 1924; 1925), Director of Research Lab., (for mail), A. S. H. & V. E., U. S. Bureau of Mines, 4800 Forbes St., and 1136 Murray Hill Ave., Pittsburgh, Pa.

HOULISTON, George Baillie, (Associate 1928), Sales Engr., (for mail), Warren Webster & Co., 919 Provident Bank Bldg., Cincinnati, O., and 33 Tower Place, Ft. Thomas, Ky.

HOUPT, George A., (1916), Pres., (for mail), Phila. Piping & Equipt. Co., 1605 Rockland St., Philadelphia, and 9 N. York Rd., Willow Grove, Pa.

HOWATT, John,* (1915), Chief Engr., (for mail), Board of Education, 650 S. Clark St., and 7006 Bennett Ave., Chicago, Ill.

HOWE, Willis W., (Associate 1917), Sales and Various Special Work, American Radiator Co., 816 S. Michigan Ave., Chicago, Ill.

HOWELL, Frank B., (1920), American Radiator Co., (for mail), 40 West 40th St., and 15 Central Park, W., New York, N. Y.

HOWELL, Lloyd, (1915), Chief Engr., (for mail), American Foundry & Furnace Co., 915 E. Washington St., and 1601 E. Washington St., Bloomington, Ill.

HOYT, William B., (1919), Sales Mgr. and Secy., National Pipe Bending Co., River and Lloyd Sts., New Haven, and 39 Clifford St., Whitneyville, Conn.

HUBBARD, Allen, (1919), Consulting Engr., (for mail), Hollis French & Allen Hubbard, 210 South St., Boston, and 51 Montvale Rd., Newton Center, Mass.

HUBBARD, G. W., (1911), Chief Mech. Engr., (for mail), Graham, Anderson, Probst & White, 1417 Railway Exch., Chicago, and 710 Bonnie Brae, River Forest, Ill.

HUBBARD, Nelson B., (1919), Engr., (for mail), Hubbard & Wagschal, Engrs., 1346 Broadway, and 2985 Blaine Ave., Detroit, Mich.

HUBERT, Jack W., (1924), Pres., (for mail), Barron-Hubert Co., Inc., 243 West 68th St., and 316 West 93rd St., New York, N. Y.

HUCH, Aloysius J., (1919), Gen. Mgr. of Sales, (for mail), Central Supply Co., 312 S. Third St., and 4037 Harriet Ave., Minneapolis, Minn.

HUCKEL, Frank, Jr., (1920), Mgr. Htg. Dept., Keystone Supply & Mfg. Co., 907 N. Ninth St., Philadelphia, and (for mail), 5335 Wingohocking Ter., Germantown, Pa.

HUCKER, Joseph H., (1921), Sales Repr., 2013 Sansom St., Philadelphia, and (for mail), 715 Stanbridge St., Norristown, Pa.

HUGHES, Willard C., (1921), (for mail), Wicks-Hughes & Co., 224 Genesee St., and 16 Cottage Place, Utica, N. Y.

HUGHSON, Harry Henry, (1927), Engrg. Salesman, The Coon-DeVisser Co., 2051 W. Lafayette and 58 Florence Ave., Detroit, Mich.

HUMPHREY, Dwight E.,* (1921), Htg. and Vtg. Engr., (for mail), Goodyear Tire & Rubber Co., Akron and 121 Harrison Ave., Cuyahoga Falls, O.

HUMPHREYS, Aurelius E., (1911), Mgr., (for mail), O'Mara Heating Co., 504 Victoria Bldg., and 4121 Flora Blvd., St. Louis, Mo.

HUNGER, Robert F., (1927), (for mail), Davidson, & Hunger, 1302 Land Title Bldg., Philadelphia, and 107 Long Lane, Stonehurst, Pa.

HUNT, Phil M., (1922), Htg. and Vtg. Engr., Crane Co., 90 South St., Newark, N. J.

HUNT, Richard B., (1912), Sales Engr., American Radiator Co., 414 S. Fourth Ave., Mt. Vernon, N.Y.

HUNTER, H. R., (Associate 1925), Bldg. Supt., (for mail), Jewelers Building Corp., 36 West 47th St., New York, N. Y., and 209-74–112th Ave., Bellaire, L. I.

HURLEY, Joseph C., (1915), Pres., (for mail), Petroleum Fuel Engine Co., 4028 Filbert St., Philadelphia, and 134 Landsdowne Court, Lansdowne, Pa.

HUSBAND, Edward Woods, (1922), Htg. Engr., 807 Union Trust Co., Bldg., and (for mail), 114 Corinth St., Providence, R. I.

HUTTON, William, (1919), Pres., (for mail), Hutton Bros. Co., 9 Union St., and 28 Spring St., Winsted, Conn.

HUTZEL, A. F., (1916), (for mail), Hutzel & Co., 119 E. Washington St., and 2115 Wallingford Rd., Ann Arbor, Mich.

HUTZEL, Hugo F., (1918), (for mail), American Radiator Co., 1901 South 11th St., Springfield, Ill., and 64 N. Long St., Williamsville, N. Y.

HUTZEL, Max H., (1923), Vice-Pres. and Secy., (for mail), Hutzel & Co., Hutzel Bldg., and 731 N. Elm St., Muncie, Ind.

HUTZEL, Victor C., (1923), Treas., (for mail), Hutzel & Co., Hutzel Bldg., and 715 N. Elm St., Muncie, Ind.

HUZZARD, Edward C., (Associate 1924), Mgr. and Asst. Treas., Fleck-Marshall Co., Hazel and Water Sts., and (for mail), 710 New Holland Ave., Lancaster, Pa.

HYMAN, Wallace M., (1920), Vice-Pres., (for mail), Reis & O'Donovan, Inc., 253 West 28th St., and 210 West 70th St., New York, N. Y.

HYNES, Lee P.,* (1919), 30 Church St., New York, N. Y.

I

ICKERINGILL, John, (1923), Sales Engr., Spencer Heater Co., 16th and Sansom St., Philadelphia, and 235 Rector St., Roxborough, Pa.

IDDLES, Alfred, (1921), Vice-Pres., Day & Zimmermann Engrg. & Constr. Co., 112 N. Broad St., Philadelphia, and (for mail), 304 Conestoga Rd., Wayne, Pa.

ILLIG, Walter Richard, (Associate 1927), Mgr., Plbg. Dept., The Jennison Co., 17 Putnum St., and 47 Arlington St., Fitchburg, Mass.

IMPEY, Paul F., (Junior 1921; Associate 1925), Htg. Engr., 2623–78th Ave., Elmwood Park, Cragin P. O., Chicago, Ill.

INGALLS, F. D. B., (1906), Htg. and Sales Engr., (for mail), 136 Federal St., Boston, and 1 Hopkins St., Reading, Mass.

INGELS, Margaret M.,* (Junior 1918; 1923), Research Engr., New York Commission on Ventilation, Rm. 318, City Hall, Syracuse, N. Y.

INNIS, Helen R., (Junior 1918; 1921), Largent, W. Va.

IRELAND, Thomas Hilton, (1923), Sales Engr., Crane Co., 23 West 44th St., New York, and (for mail), 69 Cedar Ave., Rockville Center, L. I., N. Y.

IRWIN, Clarence W., (1924), 826 Campbell Ave., Waterloo, Ia.

ISSERTELL, Henry G., (Associate 1912; 1913), Supervising Engr., General Elec. Co., (for mail), 120 Broadway, and 825 West 180th St., New York, N. Y.

J

JACKSON, Charles H., (1923), Sales Engr., Bayley Mfg. Co., 732 Greenbush St., and 614 Farwell Ave., Milwaukee, Wis.

JACKSON, Charles J., (Associate 1912), Vice-Pres. and Local Mgr., Jenkins Bros., 646 W. Washington Blvd., Chicago, Ill.

JACKSON, George O., (Associate 1928), Pres., Jackson Engrg. Co., 37 S. Capitol Ave., Indianapolis, Ind.

JACKSON, J. O., (Associate 1928), Pres., (for mail), Jackson Supply Co., 333 W. Ohio St., and 5258 Washington Blvd., Indianapolis, Ind.

JACKSON, Jonathan William, (Associate 1927), Mgr., (for mail), Pierce Co., 41 W. Spring St., and 12 West Ave., Gainesville, Ga.

JACKSON, Marshall S., (1919), Repr., (for mail), 232 Delaware Ave., and 108 Larchmont Rd., Buffalo, N. Y.

JACKSON, Tandy L., (Junior 1926), 2036 North 22nd St., Cleveland, O.

JACOBUS, David S., Dr., (1916), Advisory Engr., Babcock & Wilcox Co., 85 Liberty St., New York, N. Y.

JALIEN, John J., (1922), Engr., American Gas Products Corp., 376 Lafayette St., and (for mail), 320 Central Park West, New York, N. Y.

JANET, Harry L., (1920), Engr., (for mail), Carrier Engrg. Corp., 750 Frelinghuysen Ave., Newark, N. J., and 688 Decatur St., Brooklyn, N. Y.

JARDINE, Douglas Connell, (Associate 1926), Htg. Contracting., Jardine & Knight Plbg. & Htg. Co., 312 N. Custer, and 1731 N. Nevada, Colorado Springs, Colo.

JARVIS, George E., (1923), Secy., Htg. and Vtg. Engr., A. E. Holmes & Bros. Co., (for mail), 911 Banks Ave., and 1626 Baxter Ave., Superior, Wis.

JAYNES, Eubertis L., (1918), Pres. and Treas., Michigan Warming & Ventilating Co., 363 Hauseman Bldg., Grand Rapids, Mich.

JELLETT, Stewart A.,* (Charter Member; Presidential Member), (Pres. 1895; Board of Managers 1896-1897; Secy. 1898; Board of Managers 1899), Pres., Stewart A. Jellett Co., 1200 Locust St., Philadelphia, and 6701 Lincoln Drive, Mount Airy, Philadelphia, Pa.

JENKINS, Harry E., (Associate 1923), Sales Mgr., Radiator Div., (for mail), Winchester Repeating Arms Co., and 436 Whalley Ave., New Haven, Conn.

JENNINGS, Irving C., (1924), Pres., (for mail), Nash Engrg. Co., and 138 Flax Hill Rd., S. Norwalk, Conn.

JENNINS, Harry H., (1901), Managing Director, E. Oldroyd & Co., Ltd., Black Bull St., and 15 Grange View, Chapeltown Rd., Leeds, Eng.

JENSON, Jean S., (1912), Consulting Engr., (for mail), 431 S. Dearborn St., and 1634 West 106th St., Chicago, Ill.

JOHN, Benjamin F., (1920), Pres., (for mail), Benjamin F. John Co., 1003 Race St., and 881 North 24th St., Philadelphia, Pa.

JOHNS, Harold Byron, (Junior 1927; 1928), Mgr., House Htg. Div., Peoples Gas, Light & Coke Co., 122 S. Michigan Ave., Chicago, and (for mail), 543 N. Elmwood Ave., Oak Park, Ill.

JOHNSEN, Henry, (Associate 1927), Htg. Contractor, 51 Raleigh Ave., W. New Brighton, S. I., N. Y.

JOHNSON, Carl W., (1912), Pres., (for mail), C. W. Johnson, Inc., 211 N. Desplaines St., and 1809 Morse Ave., Chicago, Ill.

JOHNSON, Donald H., (Junior 1927), Sales Engr., (for mail), C. A. Dunham Co., 450 E. Ohio St., Chicago, and 825 Main St., Evanston, Ill.

JOHNSON, Edgar Engman, (1926), Sales Engr., (for mail), Buffalo Forge Co., 490 Broadway, and 200 Loring Ave., Buffalo, N. Y.

JOHNSON, Edward B., (1919), Sales Engr., Staten Island Supply Co., 1390 Richmond Ter., and (for mail), 154 Wardwell Ave., W. New Brighton, N. Y.

JOHNSON, Fred W., (1916), Vice-Pres., (for mail), Johnson, Larsen & Co., 6530 Beaubien, Detroit, and R. F. D. No. 4, Birmingham, Mich.

JOHNSON, Helge Samuel, (Junior 1927), Sales Engr., (for mail), The Coon-DeVisser Co., 2051 W. Lafayette Blvd., and 156 W. Margaret St., Detroit, Mich.

JOHNSON, James M., (Associate 1928), Sales Engr., Frederick, Trangott & Allen, 152 North 15th St., and (for mail), 825 North 24th St., Philadelphia, Pa.

JOHNSON, Ralph B., (1922), Sales Engr., (for mail), 1100 E. Douglas Ave., Wichita, Kans., and 2117 East 68th St. Ter., Kansas City, Mo.

JOHNSON, Royster H., (1927), Sales Engr., Mfg. Repr., 660 College St., Jacksonville, Fla.

JOHNSON, Tracy R., (1924), The Trane Co., and 626¼ S. Fourth St., LaCrosse, Wis.

JOHNSTON, James Ambler, (1912), Partner, (for mail), Carneal & Johnston, 806 Va. Ry. & Power Bldg., and Massie Rd., Windsor Farms, Richmond, Va.

JOHNSTON, R. E., (Associate 1926), Sales Engr., Taylor Forbes Co., Ltd., 1070 Homer St., and (for mail), 3342–33rd Ave., W., Vancouver, B. C.

JOHNSTON, William B., (Associate 1916; 1921), Vice-Pres., (for mail), Ideal Furnace Co., 2995 E. Grand Bldg., and 19450 Glouster Drive, Palmer Woods, Detroit, Mich.

JOHNSTON, William H., (1924), Pres., (for mail), Johnston Htg. Co., 332 East 47th St., New York, and 19 Magnolia Ave., Larchmont, N. Y.

JONES, Alfred, (1928), Dir. of Research, (for mail), Armstrong Cork Co., P. O. Box 565, and 402 President Ave., Lancaster, Pa.

JONES, Alfred L., (1926), Supt., Htg. and Power Constr., Alfred Penovi & Sons, 89 Railroad Ave., Greenwich, and (for mail), R. F. D. No. 28, Cos Cob, Conn.

JONES, Bernard G., (1928), Chief Engr., (for mail), Acme Elec. Co., Ltd., and Acme Engrg. Co., 148 Princess St., and 588 Lipton St., Winnipeg, Man., Can.

JONES, Charles R., (1928), Pres. and Mgr., Jones Supply Co., Siloam Springs, Ark.

JONES, Edwin, (Junior 1924), Engr. and Estimator, (for mail), Watt Plbg., Htg. and Supply Co., P. O. Box 582, and 1436 East 17th Place, Tulsa, Okla.

JONES, Edwin A., (1919), Contracting Engr., L. J. Mueller Furnace Co. 197 Reed St., and 1595 Frederick Ave., Milwaukee, Wis.

JONES, Edwin F., (1923), Consulting Engr., (for mail), 301 Zenith Bldg., and 116 E. Fourth St., St. Paul, Minn.

JONES, Ernest, (Associate 1925), Dist. Mgr., (for mail), B. F. Sturtevant Co., 423 Dwight Bldg., and 4630 Wornall Rd., Kansas City, Mo.

JONES, Ernest F., (1923), Mgr. Htg. Dept., (for mail), Kellogg-Mackay Co., 1351 West 37th Place, and 1431 Lunt Ave., Chicago, Ill.

JONES, Harold L., (1920), Asst. Supt., (for mail), The W. W. Farrier Co., 44 Montgomery St., Jersey City, and 11 Cambridge Rd., Glen Ridge, N. J.

JONES, Louis T., (1921), Salesman, 3700 Highland Ave., Drexel Hill, Delaware Co., Pa.

JONES, Raymond E., (1919), Pres., Haynes Selling Co., Inc., 2013 Sansom St., Philadelphia, Pa., and 39 W. End Ave., Haddonfield, N. J.

JONES, William T., (1915), (Council 1925-1928), Partner, Barnes & Jones, 126 Brookside Ave., Jamaica Plain, and (for mail) ,11 Rossmere St., Newtonville, Mass.

JOYCE, Walter P., (Associate 1924), Htg. Engr., 2039 Hardesty Ave., Kansas City, Mo.

JUNG, John S., (Associate 1923), Htg. Contractor, 554 Layton Blvd., Milwaukee, Wis.

JUNKERS, Prof. Hugo, (1925), Pres.. (for mail), Junkers-Werke, Mauptburo, and 21 Kaiserplatz, Dessau, Germany.

JUTTNER, Otto J., (1915), Pres., (for mail), Juttner Heating Co., 43 Jefferson St., Milwaukee, and Elks Club, Juneau Park, Wis.

K

KAMMAN, Arnold R., (Junior 1921; Associate 1925), Engr., John W. Danforth Co., 72 Ellicott St., Buffalo, and (for mail), Wanakah, Erie Co., N. Y.

KAMMERER, William C., (1923), Mech. Engr., Hadlow, Hughes, Hick & Conrad, 1301 Union Mortgage Bldg., Cleveland, and (for mail), 13963 Clifton Blvd., Lakewood, O.

KAPPEL, George W., (1921), Pres. and Treas., (for mail), Camden Heating Co., 8 Market St., Camden, and 347 King's Highway W., Haddonfield, N. J.

KAPPLER, Herman C., (1927), Educational Dir., (for mail), York Htg. and Vtg. Corp., 16th and Sansom Sts., Philadelphia, and 211 Wayne Ave., Narberth, Pa.

KARLSON, Alfred F., (1918), Chief Engr., (for mail), Parks-Cramer Co., 970 Main St., Fitchburg, and 186 Prospect St., N. Leominster, Mass.

KASTELLO, August, (1923), Mgr., (for mail), C. A. Dunham Co., Ltd., 904 New Birks Bldg., and 112 Rutland Ave., Town of Mt. Royal, Montreal, Que., Can.

KATSUMOTO, Eijiro, (1926), Pres., (for mail), Katsumoto & Co., Engrs. and Contractors, 29, Awajicho, and 3 Kirishimacho, Darien, S. Manchuria, China.

KAUFFMAN, Rufus, (1921), Htg. Engr., (for mail), 4308 N. Broad St., and 326 W. Seymour St., Philadelphia, Pa.

KAYSING, Harry C., (1926), Engr., Hester-Bradley Co., 4200 Forest Park Blvd., St. Louis, and 7405 Lyndover Place, Maplewood, Mo.

KEASBEY, Aertsen Parry, (1922), Vice-Pres. and Gen. Mgr., (for mail), Robert A. Keasbey Co., 445 West St., New York, N. Y., and 298 Park St., Montclair, N. J.

KEENAN, P. Frank, (Associate 1921), Pres., (for mail), Leo Flush Valve Co., 331 Madison Ave., New York, and 283 Burns St., Forest Hills, L. I.

KEENEY, Frank P., (Associate 1915), Pres., Domestic Engrg., 1900 Prairie Ave., Chicago, Ill.

KEHM, August, (1901), (Board of Governors 1908; 1911; 1st Vice-Pres. 1909), Pres.. Kehm Bros. Co., 51 E. Grand Ave., and 1336 Dearborn Pkwy., Chicago, Ill.

KEHM, Horace Stevens, (1928), Engr. and Salesman, Kehm Bros. Co., 51 E. Grand Ave., and 2337 Commonwealth Ave., Chicago, Ill.

KEISER, Walter, (Associate 1920), Vice-Pres., (for mail), Keiser Equipment & Engrg. Co., 580 Arcade Bldg., and 7411 Parkdale Ave., St. Louis, Mo.

KELBLE, Frank R., (1928), Mgr. and Htg. Engr., (for mail), The Huffman-Wolfe Co., 5217 Germantown Ave., Philadelphia, and Glenside, Pa.

KELLEY, James J., (Associate 1924), Vice-Pres., (for mail), Ballard Oil Co., 535 Commonwealth Ave., Boston, and 142 Governors Ave., Medford, Mass.

KELLOGG, Alfred,* (1916), (Council 1920-1921; 1923-1924), (for mail), 89 Franklin St., Boston, and 6 Hawthorne St., Waverly, Mass.

KELLOGG, Hosford D., (Associate 1916), Mgr., (for mail), H. B. Smith Co., 17th and Arch Sts., Philadelphia, and Haverford, Pa.

KELLOGG, Thomas M., (Associate 1923), Mgr. Htg. Dept., (for mail), The Bishop & Babcock Co., 444 Lafayette St., New York, and 23 Roxbury Rd., Scarsdale, N. Y.

KELLY, Hugh, (1927), Mgr., (for mail), H. Kelly & Co., Ltd., 10041-101 A Ave., and 10235–124th St., Edmonton, Alberta, Can.

KELLY, John G., (Associate 1919), 210 East 45th St., New York, and (for mail), 374 Park Ave., Yonkers, N. Y.

KENT, Laurence F., (Junior 1924), Pres. and Gen. Mgr., (for mail), Moncrief Furnace Co., P. O. Box 1673, Atlanta, and R. F. D. No. 2, Smyrna, Ga.

KERN, Raymond T., (1927), Chief Engr., Jennison Co., Fitchburg, and (for mail), 51 Claflin St., Leominster, Mass.

KERNEY, Thomas F., (Junior 1925), Engr., (for mail), H. Berkeley Hackett, Consulting Engr., 1001 Public Ledger Bldg., and 4522 N. Reese St., Philadelphia, Pa.

KERSHAW, Melville G., (Junior 1921; Associate 1926), Designing Engr., du Pont Engrg. Co., Wilmington, Del., and 3957 N. Percy St., Philadelphia, Pa.

KERSJES, William, (1922), Pres. and Gen. Supt., Wheeler Blaney Co., 249 N. Burdick St., and (for mail), 728 Clinton St., Kalamazoo, Mich.

KEYES, Robert E., (1913), Construction Engr., (for mail), Drying Systems, Inc., 1800 Foster Ave., Chicago, Ill., and 2497 Grand Ave., New York, N. Y.

KEYS, George Walter, (Associate 1927), Mech. Draftsman, Louis T. Klauder, Consulting Engr., 1300 Bankers Trust Bldg., Philadelphia, and (for mail), 518 Van Kirk St., Crescentville, Philadelphia, Pa.

KIEFER, Carl J., (1922), Consulting Engr., 901 Schmidt Bldg., Cincinnati, O.

KIEFER, Elmer Joseph, Jr., (Junior 1928), H. C. Archibald Co., 108 N. Sixth St., Stroudsburg, Pa.

KIEWITZ, Arthur A., (1912), Htg. Engr., 23-80 Chauncey St., Astoria, L. I., N. Y.

KIEWITZ, Conway, (1907), Engr., N. Y. Board of Education, Flatbush Ave. and Concord St., Brooklyn, and 70 King St., Floral Park, L. I., N. Y.

KILBY, Roger E., (1926), Supt., (for mail), Northwestern Htg. & Plbg. Co., 1465 Sherman Ave., and 1010 Lake St., Evanston, Ill.

KILLIAN, Maurice A., (1922), Pres., Glanz & Killian Co., 1761 Forest Ave., W., and 4400 Leslie Ave., Detroit, Mich.

KIMBALL, Charles W., (1915), Richard D. Kimball Co., 6 Beacon St., Boston, and 65 Prescott St., W. Medford, Mass.

KIMBALL, Dwight D.,* (1908), (Presidential Member), (Pres. 1915; Board of Governors 1912; 1913; 2nd Vice-Pres. 1914; Council 1914-1916), Consulting Engr., (for mail), 101 Park Ave., New York, and 230–23rd St., Jackson Heights, L. I., N. Y.

KIMBALL, Walter C., (1927), 12 Norwood Ave., Summit, N. J.

KING, Thomson, (1923), Vice-Pres., The Peerless Heater Co., Boyertown, and 834 High St., Pottstown, Pa.

KINGSLEY, Edwin A., (1926), Consulting Engr., (for mail), 101 Park Ave., New York, N. Y., and 261 Ridge Rd., Rutherford, N. J.

KINNER, J. E., (1924), Bryant Heater & Mfg. Co., 314–71st Euclid Bldg., 716 Euclid Ave., Cleveland, and 14502 Clifton Blvd., Lakewood, Cleveland, O.

KIPE, J. Morgan, (1919), Br. Mgr., (for mail), Spencer Heater Co., 609 Otis Bldg., Philadelphia, and Williamsport, Pa.

KIRK, Charles D., (1909), Mgr., Chas. D. Kirk Co., Sargent and Colleen Sts., and 774 McMillan Ave., Winnipeg, Manitoba, Can.

KIRK, George H., (1906), Htg. Contractor 6711 Wentworth Ave., Chicago, Ill.

KIRK, Leonard G., (1923), Pres., L. G. Kirk Co., Inc., 441 West 50th St., New York, N. Y., and 859 Boulevard E., Weehawken, N. J.

KIRMES, Edwin W., (1923), Vice-Pres. and Chief Engr., (for mail), Walworth-English-Flett Co., 81 Commercial Wharf, Boston, and 29 Oakland St., Melrose, Mass.

KISSICK, J. J., (1918), Chief of Bureau of Operation, Board of Education, Sixth and Rockwell Ave., and (for mail), 1768 Wayside Rd., Cleveland, O.

KITAURA, Shigeyuki, (1918), Mech. Engr., Monopoly Bureau, Dept. of Finance, Tokyo, Japan.

KITCH, Stanley B., (Junior 1925), Sales Engr., The Trane Co., 844 Rush St., Chicago, and (for mail), 3330 Wesley Ave., Berwyn, Ill.

KITCHELL, Herbert N., (Associate 1926), Mgr. Htg. Dept., (for mail), Crane Co., 824 Broadway, and 4528 Circle Ave., Cincinnati, O.

KITCHEN, Francis A., (Juhior 1923), Sales Engr., (for mail), John H. Kitchen Co., 1012 Pioneer Trust Bldg., and 5039 Wyandotte St., Kansas City, Mo.

KITCHEN, John H., (1906), Htg. and Vtg. Engr., (for mail), John H. Kitchen & Co., Pioneer Trust Bldg., 1016 Baltimore Ave., and 5015 Westwand Terrace, Kansas City, Mo.

KITTLE, F. Carlton, (1923), Htg. Draftsman, (for mail), Lord & Burnham Co., and 98 Harding Ave., White Plains, N. Y.

KLAUS, Louis J., (Junior 1921), Asst. Htg. Engr., Socony Burner Corp., 26 Broadway, New York, and (for mail), Farmingdale, L. I., N. Y.

KLEIN, Albert R., Dr., (1920), Mgr., Carrier Lufttechnische Gesellschaft, Langestrasse 61, and (for mail), Panoramastrasse 23, Stuttgart, Germany.

KLEIN, Edward W., (1917), S.E. Dist. Mgr., (for mail), Warren Webster & Co., 618 Atlantic Trust Bldg., and 825 Myrtle St., Atlanta, Ga.

KLIE, Walter, (1915), Pres., (for mail), The Smith & Oby Co., 6107 Carnegie Ave., Cleveland, and 18411 S. Woodland Rd., Shaker Heights, Cleveland, O.

KLINE, Walter J., (1912), Sales Engr., (for mail), American Dist. Steam Co., N. Tonawanda, and 186 Pine St., Lockport, N. Y.

KLONOWER, Arthur A., (1920), Mgr., J. S. Cassedy Co., 133 Austin St., and 244 Brattle St., Cambridge, Mass.

KLOTZ, Albert William, (Associate 1927), Engr., Fleck-Marshall Co., 766 E. Third St., Williamsport, and (for mail), 1103 W. Mountain Ave., S., Williamsport, Pa.

KNAB, Edward A., (Associate 1927), Htg. Engr., 1575 Cramer St., Milwaukee, Wis.

KNIGHT, Alvin B., (Associate 1916), (for mail), Warren Webster & Co., 7402 Woodward Ave., and 19501 Burlington Drive, Detroit, Mich.

KNOWLES, Arthur F., (Associate 1914), Knowles Mushroom Ventilator Co., (for mail), 202 Franklin St., New York, N. Y., and 135 Haddon Place, Upper Montclair, N. J.

KOCH, Harry O., (1916), Vice-Pres., American Htg. & Vtg. Co., 1505 Race St., Philadelphia, Pa.

KOEHLER, George T., (1923), Br. Mgr., Richmond Radiator Co., 1480 Broadway, New York, N. Y., and (for mail), 1111 Market St., Harrisburg, Pa.

KOHR, Raymond K., (Junior 1927; Associate 1928), Steamfitter, Chas. N. Brown & Co., Lafayette Bldg., Fifth and Chestnut Sts., Philadelphia, Pa., and 3631 Westfield Ave., Camden, N. J.

KOITHAN, William S., (1913), Sales Engr., (for mail), Koithan & Pryor, 39 Cortlandt St., New York, N. Y., and 46 Linden Place, Summit, N. J.

KORN, Charles B., (1922), Member of Firm, Reber-Korn Co., 817 Cumberland St., and 1022 S. Eighth St., Allentown, Pa.

KOTTCAMP, Horace A., (1915), Pres. and Gen. Mgr., Chambersburg Construction Co., 139 N. Second St., and (for mail), Philadelphia Ave., and Kenwood Rd., Chambersburg, Pa.

KRATZ, Alonzo P.,* (1925), Research Prof., Dept. of Mech. Engrg., (for mail), University of Illinois, and 1003 Douglas Ave., Urbana, Ill.

KREISSL, Hans George, (1925), Engr., (for mail), American Radiator Co., 816 S. Michigan Ave., and 630¼ Cornelia Ave., Chicago, Ill.

KREITNER, William, (Junior 1926), Service Engr., Milwaukee Valve Co., Grand Central Terminal, New York, and (for mail), 108 Linden St., Brooklyn, N. Y.

KRIEBEL, Arthur E., (1920), Service Engr., (for mail), Haynes Selling Co., 2013 Sansom St., Philadelphia, and Berwyn, Chester Co., Pa.

KRIEBEL, John H., (Associate 1921), Sales Engr., Grinnell Co., Inc., 2032 Commercial Trust Bldg., Philadelphia, and 708 Blythe Ave., Drexel Hill, Pa.

KRUEGER, James I., (1921), Mfgr's. Agent, (for mail), Illinois Engrg. Co., 417 Market St., Suite 320, and 2236 Jackson St., Apt. 2, San Francisco, Calif.

KUHLMANN, Rudolf, (1928), Pres., Thermo-Service, Inc., 101 Park Ave., New York, and (for mail), 47 Lockwood Ave., New Rochelle, N. Y.

L

LAGODZINSKI, Harry J., (Junior 1920), Sales Engr., (for mail), Ilg Elec. Vtg. Co., 324 W. Monroe St., and 3628 N. Tripp Ave., Chicago, Ill.

LANCE, Joseph F., (1923), Harrigan & Reid, 1365 Baker St., and 2491 Clairmount Ave., Detroit, Mich.

LANDERS, John J., (Junior 1924), Engr., (for mail), U. S. Radiator Corp., 303 Crosby Bldg., and 823 Smith St., Buffalo, N. Y.

LANE, Alfred M., (1916), Pres., (for mail), Monarch Metal Products Co., 5020 Penrose St., and 4238 Lafayette Ave., St. Louis, Mo.

LANE, Edward K., (1916), Owner, (for mail), Lane-Bowen Co., 201 Seventh St., and 333 Fourth St., Lorain, O.

LANG, Lawrence P., (Junior 1925), Htg. Engr., (for mail), Warren Webster & Co., 549 W. Washington St., and 1108 Balmoral Ave., Chicago, Ill.

LANGDON, J. D., (1920), 2030 Fifth Ave., Pittsburgh, Pa.

LANGENBERG, Everett B., (1914), (Council 1926), Vice-Pres., Langenberg Mfg. Co., 4519 N. Euclid Ave., and 6625 Water Ave., St. Louis, Mo.

LANGLEY, Frank P., (Associate 1926), Dist. Mgr., The Trane Co., 3628 Main St., Buffalo, and (for mail), 26 Berryman Drive, Snyder, N. Y.

LANNING, E. K., (Associate 1927), Asst. Secy. and Sales Mgr., (for mail), Warren Webster & Co., Camden, and Clayton, N. J.

LaPRAIRIE, Charles, (1926), Repr., (for mail), Crane, Ltd., 1170 Beaver Hall Sq., Montreal, and 51 Bowen Ave., N. Sherbrooke, Que., Can.

LARIMER, G. B., (1915), 751 S. Windsor Blvd., Los Angeles, Calif.

LARIMER, Wm. McCoy, (1922), Mgr. Htg. Dept., (for mail), Crane O'Fallon Co., P. O. Box 239, and 159 W. Second Ave., Denver, Colo.

LARSON, Gustus L.* (1923), Prof. Steam and Gas Engrg., (for mail), Univ. of Wisconsin, and Route 7, Madison, Wis.

LARSON, J. M., (1924), (for mail), National Regulator Co., 2301 Knox Ave., and 3541 Wrightwood Ave., Chicago, Ill.

LARSON, W. C., (1925), Htg. and Vtg. Engr., Narowitz Htg. & Vtg. Co., 1711 Park Ave., and (for mail), 4224 N. Winchester Ave., Chicago, Ill.

LATHAM, George, (1924), Engr. and Supt. of Plant, Edmonton Public School Board, 518 Civic Block, and 11317–91st St., Edmonton, Alberta, Can.

LATHROP, Dr. Elbert C., (1926), Director Research Dept., (for mail), The Celotex Co., 645 N. Michigan Ave., and 2322 East 70th Place, Chicago, Ill.

LAU, Anton S., (1926), Consulting Engr., 51 East 42nd St., New York, N. Y., and (for mail), 35 Woodland Rd., Bloomfield, N. J.

LAUTENSCHLAGER, Fred, (1915), Vice-Pres. and Treas., Kroeschell Boiler Co., 4211 Diversey Ave., and 3846 Alta Vista Ter., Chicago, Ill.

LAWTON, Frank C., (1928), Mgr. Htg. Dept., Frank A. McBride Co., 327 Grand St., Paterson, and (for mail), 145 Buena Vista Ave., Hawthorne, N. J.

LEAHY, Joseph L., (Junior 1926), Sales Engr., Modine Mfg. Co., 3116 Market St., and (for mail), 5730 N. Howard St., Philadelphia, Pa.

LeBEAU, John F. (1924), (for mail), 103 Park Ave., and 158–84th Drive, New York, N. Y.

LeCOMPTE, William G., (Associate 1914), Vice-Pres., (for mail), Jenkins Bros., 80 White St., and 124 East 84th St., New York, N. Y.

LEEK, Walter, (1903), Managing Dir., Leek & Co., 1111 Homer St., and 1114 Pacific St., Vancouver, B. C.

LEES, Herbert K., (Junior 1912; 1924), Estimator, William Lees, 548 W. Washington Blvd., and 4946 Christiana Ave., Chicago, Ill.

LEGEMAN, Ralph E., (Junior 1926), Archt. and Engr., (for mail), Thole & Legeman, Archts. and Engrs., 309 American Trust Bldg., and 900 Powell Ave., Evansville, Ind.

LEILICH, Roger L., (1922), Vice-Pres. and Mgr., (for mail), Baltimore Heating Corp., 425 St. Paul Place, and 2810 Elsinor Ave., Baltimore, Md.

LEITCH, Arthur S., (1908), Pres. and Mgr., (for mail), The Arthur S. Leitch Co., Ltd., 1123 Bay St., and 421 Russell Hill Rd., Toronto, Can.

LELAND, William E., (1915), Consulting Engr., 58 Sutter St., San Francisco, Calif.

LEMMERMAN, Clarence W., (Associate 1927), New York Br., (for mail), The Ric-wil Co., Inc., 101 Park Ave., New York, and 1165–72nd St., Brooklyn, N. Y.

LENONE, Jose M., (1919), Engr., Armour & Co., General Office, U. S. Yards, and (for mail), 4808 Dorchester Ave., Chicago, Ill.

LEUSCH, Victor William, (Associate 1926), Sales Engr., Illinois Engrg. Co., Chicago, Ill., and (for mail), 1130 Diamond Ave., South Bend, Ind.

LEWIS, Edward B., (1924), Htg. and Vtg. Engr., Ellerbe & Co., Endicott Bldg., and (for mail), 2283 Commonwealth Ave., St. Paul, Minn.

LEWIS, George C., (1919), Sales Engr., American Htg. & Vtg. Co., 1505 Race St., Philadelphia, and 812 Summit Grove, Bryn Mawr, Pa.

LEWIS, J. Clifford, (1913), Mech. Engr., (for mail), Lewis & Warren, 428 S. Fifth St., and R. R. No. 1, Upper River Rd., Louisville, Ky.

LEWIS, John G., (1926), Mgr. and Partner, Lewis & Davis, 412 East 31st St., Kansas City, Mo.

LEWIS, John W., (1926), Htg. Contracting, 4019 Sansom St., and 7038 Grays Ave., Philadelphia, Pa.

LEWIS, L. Logan,* (1918), Secy., (for mail), Carrier Engrg. Corp., 750 Frelinghuysen Ave., Newark, and 724 Carlton Ave., Plainfield, N. J.

LEWIS, Samuel R.,* (1905), (Presidential Member), (Pres. 1914; Board of Governors 1909, 1912; 2nd Vice-Pres. 1910; Council 1915), Consulting Engr., (for mail), 407 S. Dearborn St., and 4737 Kimbark Ave., Chicago, Ill.

LEWIS, Thornton,* (1919), (2nd Vice-Pres. 1927; 1st Vice-Pres. 1928), (Council 1923-1926), Pres., (for mail), York Htg. & Vtg. Corp., 1541 Sansom St., Philadelphia, and 346 Calvert Rd., Merion, Pa.

LICHTY, Arthur J., (Junior 1923), Sales Engr., (for mail), C. A. Dunham Co., 804 Forsyth Bldg., Atlanta, Ga.

LICHTY, Charles P., (1920), Engr., C. P. Lichty, 507-509 North 22nd St., and 728 Cotton Ave., Birmingham, Ala.

LINDEMAN, Henry, (Junior 1923), Estimator, Baker, Smith & Co., 572 Greenwich St., New York, and (for mail), 157 Foxall St., Ridgewood, L. I., N. Y.

LINDEMUTH, Nelson Rhoads, (Associate 1924), Vice-Pres., (for mail), Lindemuth Engrg. Co., Inc., 155 N. George St., and 324 W. Jackson St., York, Pa.

LINER, John J., (Associate 1916), Pres., (for mail), Philadelphia Asbestos Co., 2010 N. Tenth St., Philadelphia, Pa., and Berlin, N. J.

LINHARD, Howard V., (Associate 1921), Sales Mgr., Anchor Pipe & Supply Co., 14430 Dexter Blvd., and (for mail), 7238 Webb Ave., Detroit, Mich.

LINN, Homer R., (1914), Engr., American Radiator Co., 816 S. Michigan Ave., Chicago, and 321 S. Ashland Ave., LaGrange, Ill.

LINTON, John P., (1927), Gen. Mgr., (for mail), The Garth Co., 50 Craig St., W., and 247 Brock Ave., N., Montreal, Q., P. Q., Can.

LIPPMAN, Orville S., (Associate 1920), Sales Repr., (for mail), The *Kellogg-Mackay* Co., 1351 West 37th Place, and 7251 Princeton Ave., Chicago, Ill.

LITTLE, Edwin R., (1916), Pres., (for mail), The E. R. Little Co., Inc., 1918-20 Fort Bldg., Detroit, and 447 Rivard Blvd., Grosse Pointe, Mich.

LIVINGSTON, Bernard B., (1927), Gas Engr., Dept., of Public Utilities, City of Richmond, and (for mail), P. O. Box 976, Richmond, Va.

LLOYD, Edward C., (1927), Chief Engr., Armstrong Cork & Insulation Co., 24th St. and Allegheny River, Pittsburgh, and 118 Maple Ave., Edgewood, Pittsburgh, Pa.

LOCKE, Hiram W., (1920), Htg. Engr. and Sheet Metal Worker, 1942 North 20th St., Philadelphia, Pa.

LOCKER, Charles W., (1916), 13579 St. Marys, Detroit, Mich.

LOCKWOOD, Edwin H.,* (1915), Asst. Prof. Mech. Engrg., Teaching and Research, Sheffield Scientific School, Yale University, 400 Temple St., and (for mail), 51 Sheldon Ter., New Haven, Conn.

LOEFFLER, Frank X., (1914), Pres., (for mail), Frank Loeffler Supply Co., 710 N. Hudson St., and 320 West 26th St., Oklahoma City, Okla.

LOH, Nan-Shee, (Junior 1927), Charge of Htg. and Sanitary, Dept. of New Shanghai Construction Co., 1309 Goidon Rd., and (for mail), S. 681 Connaught Rd., Shanghai, China.

LONDON, Irving, (Junior 1924), Engr. and Estimator, Raisler Heating Co., 129 Amsterdam Ave., New York, and 811 Crown St., Brooklyn, N. Y.

LONG, David Raymond, (1927), Director of Engrg., (for mail), Congoleum Nairn, Inc., Kearny and 117 Christopher St., Montclair, N. J.

LONGENECKER, Howard J., (1917), Treas., (for mail), York Htg. & Vtg. Corp., Bridgeport, Montgomery Co., and 1009 DeKalb St., Norristown, Pa.

LONGWELL, Henry E., (1919), Vice-Pres., Pierce, Butler & Pierce Mfg. Corp., 41 East 42nd St., New York, and (for mail), 53 Washington Sq., New York, N. Y.

LORD, Frank R., (1922), Pres., (for mail), Lord, Hawley & Hammell, Inc., 33rd and Thompson St., Philadelphia, Pa., and Edgewood Ave., Delanco, N. J.

LOVE, Clarence H., (1919), Mfgr. Agent, (for mail), Nash Engineering Co., 317 Chamber of Commerce, and 289 Norwalk Ave., Buffalo, N. Y.

LOVEGREN, H. M., (Associate 1927), Htg. Engr., (for mail), B. Hoffman Mfg. Co., 1819 St. Paul Ave., and 112–26th St., Milwaukee, Wis.

LOWNSBERY, Benjamin F., (1920), Htg. Engr., Benjamin F. Shaw Co., Second and Lombard Sts., and (for mail), 21 S. Sycamore St., Wilmington, Del.

LUCE, G. D., Jr., (1919), Mech. Engr., D. H. Burnham Co., Archts., 1900 Burnham Bldg., and (for mail), 3633 N. Harding Ave., Chicago, Ill.

LUCK, Alexander W.,* (1919), Pres. and Gen. Mgr., Reading Heater & Supply Co., Church and Woodward Sts., Reading, Pa.

LUCKE, C. E., (1924), Prof. Mech. Engrg., Executive Htg. Dept., (for mail), Columbia University, and 845 West End Ave., New York, N. Y.

LUTZ, James H., Jr., (1928), (for mail), 140 Paxton St., and 1601 Forest St., Harrisburg, Pa.

LYLE, Ernest T., (1919), Engr., (for mail), Carrier Engrg. Corp., 39 Cortlandt St., New York, N. Y., and The Braemore, 466 Commonwealth Ave., Boston, Mass.

LYLE, J. Irvine,* (1911), (Pres. 1917), (Council 1918), Treas. and Gen. Mgr., (for mail), Carrier Engrg. Corp., 750 Frelinghuysen Ave., Newark, and Plainfield, N. J.

LYMAN, Samuel E., (Associate 1924), Erecting Supt., Air Conditioning, 2021 Land Title Bldg., and (for mail), 132 North 49th St., Philadelphia, Pa.

LYMAN, William Ira, (Associate 1925), Engr., Grinnell Co., and (for mail), 225½ Scott St., Warren, O.

LYNCH, Grevirson Davis, (Student 1927), Draftsman, York Htg. & Vtg. Corp., 16th and Sansom Sts., Philadelphia, Pa., and (for mail), 43 Cedarcroft Ave., Audubon, N. J.

LYNCH, William L., (1928), Pres., (for mail), Rome-Tourney Radiator Co., and 312 N. James St., Rome, N. Y.

Mc

McCAFFREY, H. Grattan, (1922), Chief Engr., (for mail), Sheldons, Ltd., W. Main St., S., and 23 Rich Ave., Galt, Ont., Can.

McCANN, Frank G.,* (1903), (Council 1914-1915), Chief of Htg. and Vtg. Div., (for mail), Board of Education, 131 Livingston St., and 1616 E. Tenth St., Brooklyn, N. Y.

McCARTHY, Bernard J., (1925), Sales Engr., (for mail), The Trane Co., 844 Rush St., Chicago, Ill., and 2410 S. Calhoun St., Ft. Wayne, Ind.

McCARTHY, Charles J., (1919), Contractor, (for mail), Chas. J. McCarthy, 808 Otis Bldg., and 533 South 55th St., Philadelphia, Pa.

McCAULEY, James H., (1921), Contractor, 565 W. Washington Blvd., and (for mail), 3831 Lexington St., Chicago, Ill.

McCLELLAN, James E., (1922), Sales Engr., (for mail), American Blower Co., Rm. 1404, 228 N. LaSalle St., and 4645 Manor Ave., Chicago, Ill.

McCLENATHAN, Robert, (1927), Dir. Mech. Tests and Measurements, (for mail), Board of Education, Central High School Bldg., Akron, and 492 South 16th St., Cuyahoga Falls, O.

McCLINTOCK, Alexander, Jr., (Junior 1920; 1928), Junior member of firm, A. McClintock & Sons, 1937 Ridge Ave., Philadelphia, Pa.

McCLINTOCK, Alexander, Sr., (1917), Pres., (for mail), A. McClintock & Son, 1937 Ridge Ave., Philadelphia, and 121 Rochelle Ave., Wissahickon, Philadelphia, Pa.

McCLINTOCK, John L., (1917), Member of Firm, (for mail), A. McClintock & Son, 1937 Ridge Ave., and 933 E. Rittenhouse St., Philadelphia, Pa.

McCOLL, Jay R.,* (1916), (Presidential Member), (2nd Vice-Pres. 1920; 1st Vice-Pres. 1921; Pres. 1922; Council 1923), Consulting Engr., (for mail), McColl, Snyder & McLean, 2348 Penobscot Bldg., and 825 Chicago Blvd., Detroit, Mich.

McCONACHIE, Lorne Leslie, (Associate 1928), Co-Partner, Plbg. and Htg., 8817 Mack Ave., and (for mail), 1381 Maryland Ave., Grosse Pointe, Mich.

McCONNER, Charles R., (Associate 1922), Dist. Mgr., York Htg. & Vtg. Corp., 4-266 General Motors Bldg., Detroit, Mich.

McCORMACK, E. T., (Associate 1923), Mgr., (for mail), Pierce, Butler & Pierce Mfg. Corp., 600 Ogden St., and 19 Seymour Ave., Newark, N. J.

McCOY, Thomas F., (1924), Mgr., (for mail), The Powers Regulator Co., 125 St. Botolph St., Boston, and Glen Rd., Wellesley Farms, Mass.

McCREA, Lester W., (1920), (for mail), Jas. McCrea & Son, 19 N. Carrollton Ave., and 564 University Parkway, Baltimore, Md.

McCREARY, Julian Ledrew, (Associate 1928), Rm. 11, Prince Theatre Bldg., Ambridge, and Balden, Pa.

McCREERY, Hugh J., (1922), Mgr., (for mail), Combustion Engrg. Corp., Ltd., Standard Bk. Bldg., and 1921-45th Ave., W., Vancouver, B. C.

McCULLEY, David E., (Associate 1917), Pres. and Treas., (for mail), D. E. McCulley Co., 1820 St. Mary's Ave., and 5104 Cuming St., Omaha, Nebr.

McCUNE, Byron V., (1928), Sales Repr., and Engr., 101 W. Yakima Ave., and (for mail), 211 North 24th St., Yakima, Wash.

McDONALD, John J., (1927), Mgr., Mitchell Woodbury Co., 560 Atlantic Ave., Boston, and (for mail), 26 Chestnut St., Malden, Mass.

McDONNELL, Everett N., (1923), Partner, (for mail), McDonnell & Miller, Wrigley Bldg., 400 N. Michigan Blvd., and 627 Arlington Place, Chicago, Ill.

McELLROY, G. S., (1925), Engr., R. T. Withers Sons Co., 111 N. Shenango St., New Castle, and (for mail), R. F. D. 2, Glenshaw, Pa.

McEVOY, William J., (1917), Vice-Pres. and Secy., (for mail), Kitzelman Co., 3615 S. Morgan St., and 6718 Lakewood Ave., Chicago, Ill.

McFARLAND, William P., (Associate 1923), Salesman, Powers Regulator Co., 2720 Greenview Ave., and (for mail), 1106 Columbia Ave., Chicago, Ill.

McGEORGE, R. H., (1927), Mgr., (for mail), Ilg Elec. Vtg. Co., 508 Architects Bldg., and 2410 Tuxedo Ave., Detroit, Mich.

McGINNESS, J. E., (1903), Pres., (for mail), McGinness, Smith & McGinness Co., 527 First Ave., Pittsburgh, Pa.

McGLENN, G. Raymond, (1915), Secy., American Warming & Vtg. Co., 317-19 Pennsylvania Ave., and (for mail), 259 Lormore St., Elmira, N. Y.

McGRAIL, Thomas Ernest, (1926), Mgr., Htg. Dept., Crane, Ltd., and (for mail), 316 Belmore Ave., Montreal, Que., Can.

McGREGOR, George H., (1920), Mgr., (for mail), Western Htg. Co., 2250 N. Cicero Ave., Chicago, and 500 Leonard St., Park Ridge, Ill.

McGUIGAN, L. A., (Associate 1919), Salesman, Natl. Radiator Co., 1509 Arrott Bldg., and (for mail), 724 Hastings St., Pittsburgh, Pa.

McHENRY, Robert W., (1921), Estimating Engr., Empire Brass Mfg. Co., Ltd., 110 Adelaide St., W., and (for mail), 236 Eglinton Ave., E., Toronto, Ont., Can.

McHUGH, George F., (1925), 2427 Penna. Ave., Philadelphia, Pa.

McINTIRE, James F., (Associate 1914; 1915), (Council 1926), Vice-Pres., (for mail), U. S. Radiator Corp., P. O. Box 686, 1056 First Natl. Bk. Bldg., and 3261 Sherbourne Rd., Detroit, Mich.

McINTOSH, Fabian C., (Junior 1917; 1921), Br. Mgr., (for mail), Johnson Service Co., 10 E. North Diamond St., N.S., and 3335 Portole St., Pittsburgh, Pa.

McKENNA, William N., (1912), Treas., (for mail), Wm. N. McKenna Co., 79 Chestnut St., and 21 W. Cedar St., Boston, Mass.

McKIEVER, Wm. H.,* (Junior 1896; 1897), Pres., (for mail), Wm. H. McKiever, Inc., 247 West 13th St., New York, and 479 Eighth St., Brooklyn, N.Y.

McLAIN, Roland D., (1921), Htg. Engr., E. Keeler Co., 238 West St., and (for mail), 716 Vernon Ave., Williamsport, Pa.

McLAUGHLIN, Joseph Domnick, (Junior 1928), Mgr., (for mail), Braley & McLaughlin, Htg. and Vtg. Contractors, 166 Aborn St., and 45 Roslyn Ave., Providence, R. I.

McLAUGHLIN, Joseph J., (Associate 1928), Contractor, 1831 South 23rd St. Philadelphia, Pa.

McLEAN, Dermid, (1917), Consulting Engr., (for mail), McColl, Snyder & McLean, 2304 Penobscot Bldg., and 12651 Birwood Ave., Detroit, Mich.

McLEAN, Ivory D., (1924), Pres., (for mail), McLean & Cousens Co., 65 Chandler St., Boston, and 156 Coolidge St., Brookline, Mass.
McLEISH, William Scott, (Junior 1928), Engr., The Ric-wil Co., 1573 Union Trust Bldg., Cleveland, and 1604 Wagar Ave., Lakewood, O.
McLELLAND, H. Burton, (Associate 1912), Salesman, Jenkins Bros., 640 Washington Blvd., and 129 N. Menard Ave., Chicago, Ill.
McMAHON, Thomas W., (1928), Br. Mgr., (for mail), American Blower Corp., 819 Continental Bk. Bldg., and 3541 N. Meridian St., Indianapolis, Ind.
McMAHON, W. W., (Associate 1923), Eastern Mgr., (for mail), Automatic Heat Control Co., 91 Seventh Ave., and 3105 Decatur Ave., New York, N. Y.
McMICHAEL, Peter, (Associate 1925), Pres. and Mgr., Kewanee Boiler Co., Ltd., 66 Richmond St., E., and (for mail), 41 Spadina Rd., Apt. No. 7, Toronto, Ont., Can.
McMILLAN, Luther B.,* (1918), Consulting Engr., (for mail), Johns-Manville, Inc., 292 Madison Ave., and 105 East 38th St., New York, N. Y.
McMORRAN, Francis J., (1917), Chief Engr., Pecco, Inc., 2951 N. Market St., St. Louis, and (for mail), 230 E. Argonne Drive, Kirkwood, Mo.
McMURRAY, John, (1920), Pres., Iron City Htg. Co., 843 Jackson St., N.S., Pittsburgh, Pa.
McMURRER, Louis J., (Junior 1924; 1928), Draftsman, The McMurrer Co., 303 Congress St., Boston, and (for mail), 190 Harvard Circle, Newtonville, Mass.
McNAIR, Edward E., (1915), (Council 1921; 1922; 2nd Vice-Pres. 1923), Vice-Pres., (for mail), U. S. Radiator Corp., 1056 First Natl. Bk. Bldg., Detroit, Mich.
McVEHIL, Earl W., (1923), Mgr., McVehil Plbg. Co., 40 E. Wheeling St., Washington, Pa.

M

MacDADE, Ambrose H., (1923), Sales, (for mail), Burnham Boiler Corp., Bourse Bldg., Philadelphia, Pa., and 225 Haddon Ave., Westmont, N. J.
MacDOUGALL, Burgess W., (1923), Mech. Supt., State of New Jersey, State Office Bldg., Trenton, and (for mail), 219 Netherwood Ave., Plainfield, N. J.
MacKENZIE, Burt, (1924), (for mail), P. O. Box 353, and 111 Westover Ter., Greensboro, N. C.
MacKENZIE, John J., (1925), McNaughton & MacKenzie, 1029 Shaw St., and (for mail), 664 Shaw St., Toronto, Ont., Can.
MACKIE, James, (1917), Mgr., James Mackie Plbg. & Htg. Co., 357 Langside St., and 254 Montrose St., Winnipeg, Man.
MADISON, Richard D., (1926), Research Engr., (for mail), Buffalo Forge Co., 490 Broadway, and 133 Lisbon Ave., Buffalo, N. Y.
MAGINN, Peter F., (1908), P. F. Maginn & Co., 207 Fulton Bldg., Pittsburgh, Pa.
MaGIRL, Willis James, (Junior 1927), Asst. Htg. Engr., (for mail), P. H. MaGirl Fdry. & Furnace Works, 401-413 E. Oakland Ave., and 401 Willard Ave., Bloomington, Ill.
MAHONEY, David John, (Associate 1926), Br. Mgr., (for mail), Johnson Service Co., 503 Franklin St., and 1240 Delaware Ave., Buffalo, N. Y.
MAIER, George M., (1921), Engr., Planning and Research Dept., (for mail), American Radiator Co., 40 West 40th St., New York, and Apt. 54, Peldean Court, Pelham, N. Y.
MAIER, Herman F., (1926), Chief Engr. and Secy., New York Blower Co., 3166 Shields Ave., and (for mail), 7124 S. Morgan St., Chicago, Ill.
MALLIS, William, (1914), Architect and Engr., (for mail), 300 Lyon Bldg., and 1727–16th Ave., Seattle, Wash.
MALONE, Dayle G., (Associate 1925), Vice-Pres., Hardin-Lavin Co., 121 W. Pershing Rd., Chicago, and (for mail), 7015 Merrill Ave., Windsor Pk. Sta., Chicago, Ill.
MANAHAN, James E., (Junior 1926), Asst. Engr., (for mail), Bradley Htg. Co., 3834 Olive St., and 6732 Oakland Ave., St. Louis, Mo.
MANDEVILLE, Edgar W., (1914), E. W. Mandeville, Inc., 623 Parkside Ave., and (for mail), 1171 East 37th St., Brooklyn, N. Y.
MANN, Carl P., (1924), Construction Engr., Mercer Island, Seattle, Wash.
MARION, Charles A., (Associate 1926), Engr., 4155 Cass Ave., and (for mail), 742 Burlingame Ave., Detroit, Mich.
MARSCHALL, Peter J., (Junior 1927), Engr., (for mail), E. Vernon Hill Co., 121 N. Clark St., and 8228 Langley Ave., Chicago, Ill.
MARSHALL, H. Hall, (1923), Consulting Engr., (for mail), 37 West 43rd St., New York, and 63 Pine St., Garden City, N. Y.
MARTENIS, John V., (1918), Associate Prof. of Mech. Engrg., Mech. Engrg. Dept., University of Minnesota, and (for mail), 416 Harvard St., S.E., Minneapolis, Minn.
MARTIN, Albert B., (1917), Dist. Sales Mgr., (for mail), Kewanee Boiler Co., 822 W. Washington Blvd., Chicago, and 779 Vine St., Winnetka, Ill.
MARTIN, George W., (1911), Pres., (for mail), New York Service Co., 141 East 29th St., New York, N.Y., and 314 Prospect St., Ridgewood, N. J.
MARTIN, Jeremiah F., (1926), Estimator and Supt. of Construction, H. L. Graham, 60 Exchange St., and (for mail), 166 Glenwood Ave., Pawtucket, R. I.
MARTIN, O. Waldemar, (1925), Chicago Mgr., (for mail), Flax-li-num Insulating Co., 228 N. LaSalle St., Chicago, and 2235 Forest View Rd., Evanston, Ill.
MASON, James J., (1918), Salesman, (for mail), National Radiator Corp., 935 East 63rd St., Cleveland, and 936 Whitby Rd., Cleveland Heights, O.
MASON, Ray B., (1925), Sales Engr., (for mail), Kewanee Boiler Co., 2014 Wyandotte St., and LaSalle Hotel, Kansas City, Mo.
MATCHETT, James C., (1923), Vice-Pres. and Mgr., (for mail), Illinois Engrg. Co., Racine Ave., at 21st St., and 9936 W. Winchester Ave., Chicago, Ill.
MATHEY, Nicholas J., (1915), Htg. and Vtg. Engr., Mathey Plbg. Co., 31 Third Ave., N.E., LeMars, Iowa.
MATHIS, Eugene,* (1922), New York Blower Co., (for mail), New York Blower Co., Armour P. O. Sta., 32nd St. and Shields Ave., and 9151 S. Hoyne Ave., Chicago, Ill.
MATHIS, Henry, (1921), New York Blower Co., 3155 Shields Ave., and (for mail, 6226 S. Loomis Blvd., Chicago, Ill.
MATHIS, Julien W., (Associate 1921), Pres., New York Blower Co., 2248 S. Halsted St., and (for mail), 7003 S. Peoria St., Chicago, Ill.
MATHY, Joseph, Jr., (1925), Chief Engr., (for mail), R. B. Hayward Co., 1714 Sheffield Ave., and 3415 West 61st Place, Chicago, Ill.
MATSON, Taylor, (Associate 1925), Mech. Engr., Taylor Matson Co., 6141 Girard Ave., Philadelphia, Pa.
MATTHEWS, Charles Russell, (1924), Htg. Engr., (for mail), Warren Webster & Co., 76 Summer St., Boston, and (for mail), P. O. West Action, Mass., R. F. D. No. 1, Boxborough, Mass.
MATTHIESSEN, H. G. F., (1923), Sales Engr., Hoffman Specialty Co., 25 West 45th St., New York, N. Y., and (for mail), 394 Centre St., Nutley, N. J.
MATZEN, Harry B., (1919), Mgr., Carrier Engrg. Corp., 1824 Union Trust Bldg., Cleveland, and 3115 Chadbourne Rd., Shaker Heights, O.
MAUER, William J., (1919), Vice-Pres. and Sales Mgr., (for mail), Dwyer Equipt. Co., 4534 W. North Ave., Chicago, and 2525 Colfax St., Evanston, Ill.
MAURER, Edward D., (1921), Secy. and Treas., Maurer Bros. Co., 8600 Detroit Ave., Cleveland, and (for mail), 1527 Mars Ave., Lakewood, O.

MAUTSCH, Robert, (Associate 1928), Engr., Mgr., Compagnie Belge des Freins Westinghouse, Avenue Louise 97, Brussels, Belgium.
MAY, Arthur O., (Junior 1928), Sales Engr., (for mail), Stannard Power Equipt. Co., 53 W. Jackson Blvd., Chicago, and 122 Callan Ave., Evanston, Ill.
MAY, Edwin A., (1906), 171 N. Kenilworth Ave., Oak Park, Ill.
MAYER, Robert S., (1911), R. F. D. No. 1, Erie, Pa.
MAYETTE, Charles E., (1926), Service Equipt. Engr., United Engrs. & Constructors, Inc., 112 N. Broad St., Philadelphia, Pa., and (for mail), Engineers Club, Boston, Mass.
MEAD, Edward A., (1926), Sales Dept., (for mail), Nash Engrg. Co., S. Norwalk, Norwalk, Conn.
MEAD, Walter R., (1924), Dist. Sales Repr., Hoffman Specialty Co., 409 Call Bldg., San Francisco, and (for mail), 711 Highland Ave., San Mateo, Calif.
MEADOWS, Frank H., (1923), Pres., (for mail), The Meadows Heating Co., 94 Second St., and 1282 Farwell Ave., Milwaukee, Wis.
MEARA, John J., (Junior 1925), Engr., Hunt Htg. Co., 1515 Olive St., and 5046 Wabada Ave., St. Louis, Mo.
MEHAFFEY, William Chambers, (1922), Engr., Chambersburg Construction Co., Chambersburg, Pa.
MEHRING, George, (Charter Member), Pres., Mehring & Hanson, 162-166 N. Clinton St., Chicago, Ill.
MEIER, Konrad,* (1916), Consulting Engr., Rychenbergstrasse 57, Winterthur, Switzerland.
MELLON, James T. J., (1911), (Council 1915), Owner, Mellon Co., (for mail), 4419 Ludlow St., and 431 North 63rd St., Philadelphia, Pa.
MENK, Rudolph W., (1919), Mgr., Htg. Systems Div., Robinson Furnace Co., 205-207 W. Lake St. Chicago, and (for mail), 814 Clement St., Joliet, Ill.
MENSING, Frederick D., (1920), Consulting Engr., (for mail), Mensing & Co., 928 Presser Bldg., and 2845 Frankford Ave., Philadelphia, Pa.
MENZIES, Frederick Robert, (Junior 1926), New Haven Mgr., (for mail), The Trane Co., 410 Temple St., New Haven, and Long Hill, Woodbridge, Conn.
MERKEL, Fred P., (1924), Prop., (for mail), 2 Garfield Place, E. Orange, N. J.
MERRELL, Spencer Atkins, (Associate 1927), Pres., (for mail), Merrell & Co., Inc., 4424-26 Olive St., St. Louis, and 4395 McPherson, St. Louis, Mo.
MERRILL, Carl J., (1919), Treas., (for mail), C. J. Merrill, Inc., 54 St. John St., 15 Longfellow St., Portland, Me.
MERRITT, C. J., (1925), C. J. Doughty & Co., Inc., 30 Brenan Rd., W., Shanghai, China.
MERTZ, Walter A., (1919), Secy., (for mail), Kehm Bros. Co., 51 E. Grand Ave., and 3753 N. Keeler Ave., Chicago, Ill.
MERVINE, Thomas R., (1922), Mervine Bros., 616 N. Fifth St., and (for mail), 5852 N. Fifth St., Philadelphia, Pa.
MERWIN, Gile E., (Junior 1923; 1924), Htg. Engr., (for mail), Rockford Brass Works, and 1228 Rockton Ave., Rockford, Ill.
MESSMER, George E., (Junior 1925), Htg. Engr., (for mail), Bridge & Beach Mfg. Co., 4204 N. Union Blvd., and 2914 N. Euclid Ave., St. Louis, Mo.
MESTON, A. B., (Associate 1925), 201 W. Second St., Des Moines, Ia.
MEWSHAW, James P., (1923), 915 Barr Bldg., Washington, D. C.
MEYER, Frank L., (Junior 1928), Engrg. Dept., Meyer Furnace Co., and (for mail), 201 Bradley St., Peoria, Ill.
MEYER, Henry C., Jr., (1898), (Council 1915; 1916), Consulting Engr., 101 Park Ave., New York, N. Y.
MEYER, John W., Jr., (1921), Mgr. Order and Credit Depts., (for mail), American Blower Co., 6004 Russell St., and 760 Seward Ave., Detroit, Mich.
MEYER, Richard C., (1926), Sales Engr., Walter H. Eagan & Co., 315 Stephen Grand Bldg., and (for mail), 1705 Porter St., Philadelphia, Pa.
MEYERS, John, (Junior 1925; Associate 1928), Br. Mgr., (for mail), Johnson Service Co., 911 Cathedral St., and 404 Wilmslow Rd., Baltimore, Md.
MEYERS, Samuel H., (Associate 1924), Meyers Bros., 219 Hale St., and 1502 Virginia St., Charleston, W. Va.
MICKIEWICZ, Stanley John, (Junior 1928), Htg. and Vtg. Engr., Typhoon Fan Co., 345 West 39th St., and (for mail), 532 East 147th St., New York, N. Y.
MIKESH, John James, (Junior 1928), Htg. Dept. Mgr., Crane Co., (for mail), Crane Co., 400 Third Ave., N., and 4836 Nokomis Ave., S., Minneapolis, Minn.
MILES, James C.,* (1914), Vice-Pres., The Warm Air Furnace & Fan Co., 6511 Cedar Ave., Cleveland, O.
MILLAR, Rowland J., (1925), Vice-Pres. and Mgr., (for mail), Pease Foundry Co., Ltd., 118 King St., E., and 53 Oakmount Rd., Toronto, Ont., Can.
MILLER, Alan A., (Associate 1926), Htg. Dept., Hajoca Corp., 120 South 30th St., Philadelphia, and (for mail), 731 Cornell Ave., Drexel Hill, Pa.
MILLER, Charles A., (Associate 1917), Salesman, (for mail), The H. B. Smith Co., 10 East 39th St., and 2178 University Ave., New York, N. Y.
MILLER, Charles W., (Junior 1908; 1919), Pres., (for mail), Rado Co., 192 Reed St., Milwaukee, and R 1, Box 62, Menomonee Falls, Wis.
MILLER, Edwin A., (Associate 1925), Coheen Corp., (for mail), 331 Madison Ave., and Emerson Hotel, 75th St., Amsterdam Ave., New York, N. Y.
MILLER, Floyd A., (1911), Inspection Engr., U. S. Treasury Dept., 477 Federal Bldg., Chicago, Ill.
MILLER, Harry M., (1920), Htg. and Vtg. Engr., 6089-91 Plankinton Bldg., Milwaukee, and 1290 Stowell Ave., Shorewood, Wis.
MILLER, Harvey N., (1921), Dist. Mgr., (for mail), Illinois Engrg. Co., Buckeye Blower Co., 1228 Grand Rapids Natl. Bk. Bldg., and 645 Prince St., S. E., Grand Rapids, Mich.
MILLER, Henry F., (Associate 1928), Mgr., (for mail), Keasbey & Mattison Co., Rm. 200, Schaff Bldg., 15th and Race Sts., Philadelphia, and 11 S. Swarthmore Ave., Ridley Park, Pa.
MILLER, James E., (Junior 1912; 1914), Vice-Pres., (for mail), C. W. Johnson, Inc., 211 N. Desplaines St., Chicago, and 2210 Colfax St., Evanston, Ill.
MILLER, John F. G., (1916), Vice-Pres. and Treas., American Blower Co., 6004 Russell St., Detroit, Mich.
MILLER, Leo B., (1926), Partner, (for mail), McDonnell & Miller, Wrigley Bldg., Chicago, Ill.
MILLER, Merl William, (Junior 1926), Research Engr., (for mail), Trane Co., and 1132 State St., LaCrosse, Wis.
MILLER, Peter, (1926), Htg. Engr. and Estimator, Davidson & Miller, Htg. and Plbg. Contractors, 119 Broadway, Saranac Lake, N. Y.
MILLER, Robert B., (1922), Pres. and Mgr., (for mail), Miller & Brady, Inc., 210 East 38th St., New York, and 9405–95th St., Woodhaven, L. I., N. Y.
MILLER, Robert T., (Associate 1927), Chief Engr., (for mail), Masonite Corp., 504 Conway Bldg., and 1465 East 50th St., Chicago, Ill.
MILLER, Rowland Austin, (Associate 1927), Mgr., Pacific Coast Dist., (for mail), Chamberlin Metal Weather Strip Co., 1072 N. Wilton Place, Los Angeles, and 334 25th St., Santa Monica, Calif.
MILLER, Tolbert G., (Junior 1921), Supt., Herre Bros., Harrisburg, and (for mail), 11 N. Second St., Wormleysburg, Pa.

MILLER, William C., (1918), Pres., (for mail), Htg. Specialties Co., 110 Walnut St., and 4420 Sansom St., Philadelphia, Pa.

MILLIKEN, James H., (1923), Chicago Mgr., (for mail), Reed Air Filter Co., 228 N. LaSalle St., Chicago, and 1021 Ridge Court, Evanston, Ill.

MILLIS, Linn W.,* (1918), Secy. and Treas., Security Stove & Mfg. Co., 17th and Oakland Sts., and (for mail), 3534 Wabash Ave., Kansas City, Mo.

MILWARD, Robert K., (Associate 1920), Br. Mgr., (for mail), U. S. Radiator Corp., 517 Dime Bk. Bldg., and 2675 Tuxedo Ave., Detroit, Mich.

MINNICH, Harry S., (1921), Philadelphia Mgr., Richmond Radiator Co., 2241 N. American St., and (for mail), 4526 Walnut St., Philadelphia, Pa.

MITCHELL, Charles H., (1924), Engr., Barber Co., 26 Warrenton St., Boston, and (for mail), 179 Thatcher St., Mattapan, Mass.

MODIANO, Rene, (1925), Continental Sales Engr., Carrier Engrg. Co., Ltd., Elysee Bldg., 56 Rue du Faubourg, St. Honoré, and (for mail), 10, Rue Gustave Dore, Paris (17 eme), France.

MOFFETT, William S., (1907), Consulting and Construction Engr., R. F. D. 2, Staunton, Va.

MOLER, William H., (Junior 1923; 1927), Sales Engr., Carrier Engrg. Corp., Rm. 1032, Burnham Bldg., Randolph and LaSalle Sts., and 536 Arlington Place, Chicago, Ill.

MOLTZ, George N., (Associate 1925), Standard Heater Co., 320 Granfilan Blvd., Williamsport, Pa.

MONAGHAN, Thomas H., (1914), Pres., (for mail), Robert Gordon, Inc., 22 W. Austin Ave., and 623 Deming Place, Chicago, Ill.

MONDAY, Charles E., (1920), (for mail), Chas. E. Monday Co., 1323 Fairmont Ave., and 15 N. Chelsea Ave., Atlantic City, N. J.

MONIN, E. H., (1923), E. H. Monin, Inc., 70 Delaware Ave., and 669 Parkside Ave., Buffalo, N. Y.

MONROE, Harry E., (Associate 1928), Sales Engr., Excelso Products Corp., 820 S. Michigan Ave., and (for mail), 1907 East 78th St., Chicago, Ill.

MONROE, Lewis O., (Junior 1917; Associate 1925), Vice-Pres. and Gen. Mgr., Clarage Fan Co., Cor. North and Porter Sts., and (for mail), 2415 S. Westnedge St., Kalamazoo, Mich.

MONTAGNA, C. J., (1924), Pres. and Treas., C. J. Montagna, Inc., (for mail), 211 W. Olney Rd., and 1215 DeBree Ave., Norfold, Va.

MONTGOMERY, W. Ray, (Associate 1923), Co-Partner, (for mail), Montgomery Bros., 500 N. Dearborn St., and 2970 Sheridan Rd., Chicago, Ill.

MOON, L. Walter, (1915), Engr., (for mail), Bradley Htg. Co., 3834 Olive St., and 6069 Cates Ave., St. Louis, Mo.

MOORE, H. Lee, (1919), Pittsburgh Mgr., Buffalo Forge Co., Union Trust Bldg., Pittsburgh, and 7065 Flaccus Rd., Ben Avon, Pa.

MOORE, Herbert S., (Associate 1923), Sales Mgr., The Atlas Engrg. & Mach. Co., Ltd., 23 River St., and 107 Clendenan Ave., Toronto, Ont., Can.

MOORE, Raymond Francis, (Associate 1926), Architect, (for mail), 426 Mercantile Natl. Bk. Bldg., and 347 South 19th St., Cedar Rapids, Ia.

MOORE, Robert Edwin, (Associate 1928), Mgr., B. & G. Heater Div., Bell & Gossett Co., 3000 Wallace St., and 2102 Home Ave., Chicago, Ill.

MORAN, Frank E., (1922), Pres., (for mail), Ben Rigby, Inc., 2652 Elston Ave., Chicago, and 3034 S. Maple Ave., Berwyn, Ill.

MORAN, F. N., (1916), 128 W. Main St., Staunton, Va.

MORAN, Roger J., (1926), Prop., (for mail), 51 Allen, and 379 E. Utica St., Buffalo, N. Y.

MORGAN, C. Stanley, (Associate 1919), (for mail), 445 W. Larned St., Detroit, and 1036 Devonshire Rd., Grosse Point Park Village, Mich.

MORGAN, Francis H., (1912), Pres. and Treas., (for mail), J. F. Morgan & Son, Inc., 67 Blake St., and 194 Maple St., Lynn, Mass.

MORGAN, Glenn C., (1911), Partner, (for mail), Morgan-Gerrish Co., 808 LaSalle Ave., and 1722 Fremont Ave., S., Minneapolis, Minn.

MORGAN, J. Scott, (Associate 1922), Mgr., (for mail), Morgan Bros., 7227 Tioga St., and 7031 Hamilton Ave., Pittsburgh, Pa.

MORGAN, Robert C., (1915), Chief Engr., (for mail), Stewart A. Jellett Co., Engrs., 1200 Locust St., and 314 W. Seymour St., Philadelphia, Pa.

MORRILL, Raleigh Dudley, (1928), Associate Prof. Experimental Engrg., (for mail), New York University, University Heights, New York, N. Y., and Overbrook, Stamford, Conn.

MORRIS, C. Raymond, (1921), Vice-Pres., (for mail), A. & J. Friedman Supply Co., Inc., 55 Lexington Ave., Passaic, and 379–20th Ave., Paterson, N. J.

MORROW, Charles F., (Associate 1919), Mgr., (for mail), National Radiator Co., 1509 Arrett Bldg., Wood and Fourth Ave., Pittsburgh, Pa.

MORSE, C. T., (1921), Sales Mgr., American Blower Co., 6004 Russell St., and 16222 Shaftsbury Ave., Detroit, Mich.

MOSHER, Clarence H., (Associate 1919), Dist. Sales Agent, American Schaeffer & Budenberg Corp., 338 Berry St., Brooklyn, and (for mail), 423 Ashland Ave., Buffalo, N. Y.

MOSHER, Roy Bradford, (Associate 1927), Mgr., (for mail), Modine Mfg. Co., 354 Baker Bldg., and 3236 Irving Ave., S., Minneapolis, Minn.

MOSS, Edward, (1920), Supervisor, Plbg. and Htg., (for mail), New York Rapid Transit Corp., 1130 Atlantic Ave., Brooklyn, and 9053–204th St., Hollis, L. I., N. Y.

MOTEJL, J. A., (1917), Chief Engr., Board of Education and (for mail), 220–16th Ave., W., Cedar Rapids, Ia.

MOTT, Abram C., Jr., (1921), Pres., Abram Cox Co., American and Dauphin Sts., Philadelphia, Pa.

MOULDER, Albert W., (1917), Mgr., Htg., Power and Industrial Piping Div., (for mail), Grinnell Co., 260 W. Exchange St., Providence, R. I.

MOULTON, David, (1926), Mech. Engr., (for mail), Monks & Johnson, 99 Chauncy St., Boston, and 30 Meridian St., Malden, Mass.

MOWER, William P., (1924), Htg. Engr., (for mail), Warren Webster & Co., 76 Summer St., Boston, and 48 Middlesex Ave., Swampscott, Mass.

MUELLER, Paul E., (1919), Pres., (for mail), The Paul E. Mueller Co., 320 Park St., and 924 Summit Ave., Milwaukee, Wis.

MUIR, George A., (1917), Consulting Mech. Engr., 168 N. Michigan Ave., Chicago, and (for mail), 234 S. Scoville Ave., Oak Park, Ill.

MUNDER, J. F., Jr., (Junior 1924; 1927), Mgr., Trade Div., (for mail), American Blower Co., 50 Church St., New York, N. Y., and 193 River Edge Rd., Tenafly, N. J.

MUNIER, Leon L., (Junior 1915; 1919), Secy., (for mail), Wolff & Munier, Inc., 222 East 41st St., New York, and Mt. Vernon, N. Y.

MUNRO, Edward A., (1920), Htg. and Vtg. Engr., Richardson & Boynton Co., 260 Fifth Ave., New York, and 118-66 Farmers Ave., St. Albans, N. Y.

MUNSON, Morris G., (1925), Field Sales Mgr., (for mail), Herman Nelson Corp., Moline, and 805–20th Ave., E. Moline, Ill.

MURPHY, Edward T.,* (1915), Vice-Pres. and Sales Mgr., (for mail), Carrier Engrg. Corp., 39 Cortlandt St., New York, N. Y., and 1250 Montgomery Ave., Atlantic City, N. J.

MURPHY, Howard C.,* (1923), Vice-Pres., (for mail), Reed Air Filter Co., Inc., 215 Central Ave., and 2114 Edgehill Rd., Louisville, Ky.

MURPHY, Joseph Richard, (Associate 1925), Asst. to Pres., Thermal Appliance Co., Inc., 342 Madison Ave., New York, and (for mail), New Beverly Apt., B-2, Kew Gardens, L. I., N. Y.

MURPHY, William A., (1926), Sales Engr., Hoffman Specialty Co., 25 West 45th St., New York, N. Y.

MURPHY, William R., (1911), Vice-Pres. and Treas., American Htg. & Vtg. Co., 1505 Race St., Philadelphia, and 226 Valley Rd., Merion Sta., Pa.

MURRAY, Thomas F., (1923), Engr., State Architect, and 300 Washington Ave., Albany, N.Y.

MUSAUS, John, Jr., (1923), Pres., (for mail), John Musaus Sons, 5912 New Utrecht Ave., and 1108–85th St., Brooklyn, N. Y.

MUTH, Herbert, (1912), Pres. and Treas., (for mail), Muth Htg. & Engrg. Co., 4338 N. Western Ave., and 4117 Greenview Ave., Chicago, Ill.

MYERS, David R., (1923), Mgr., (for mail), Merion, Pa., and 5629–32nd St. N.W., Washington, D. C.

MYERS, George W. F., (Junior 1923; Associate 1928), Asst. Sales Mgr., York Htg. & Vtg. Corp., 1541 Sansom St., Philadelphia, and (for mail), 730 Wynnewood Rd., Ardmore, Pa.

MYRICK, James W. H., (1909), Vtg. Engr., Owner, (for mail), New England Air Conditioning Co., 53 Devonshire St., Boston, and 398 Columbia Rd., Dorchester, Mass.

N

NACEY, Harry M., (1908), Pres. and Gen. Mgr., (for mail), 927 S. State St., and 229 Lake Shore Drive, Chicago, Ill.

NADEN, Lester James, (Junior 1925), Interstate Plbg. Supply Co., 733 Broadway, and 131 Southern Blvd., Albany, N. Y.

NAROWETZ, Louis L., Jr., (Associate 1912), Contractor, Secy., (for mail), Narowetz Htg. & Vtg. Co., 1711-1717 Maypole Ave., Chicago, and 112 Park Ave., Park Ridge, Ill.

NASON, George Lewis, (Junior 1927), Draftsman, Buerkel & Co., 16-24 Union Park St., Boston, and (for mail), 31 N. Franklin St., Holbrook, Mass.

NASS, Arthur F., (1927), Secy. and Treas., (for mail), McGinness, Smith & McGinness Co., 527 First Ave., Pittsburgh, and Hillcrest and Elmhurst Ave., R. F. D. No. 8, Crafton P. O., Pa.

NATKIN, Benjamin,* (Junior 1907; 1909), Pres., (for mail), Natkin Engrg. Co., 208 Mutual Bldg., and 3725 Tracy Ave., Kansas City, Mo.

NAYLOR, Ben C., (Associate 1922), Sales Mgr., Standard Asbestos Mfg. & Insulation Co., Scott and Guinott, Kansas City, Mo.

NEAL, Harry W., (1928), Secy., (for mail), Hall-Neal Furnace Co., 1324 N. Cap Ave., and 3905 Graceland Ave., Indianapolis, Ind.

NEALE, Laurance I., (Associate 1927), Sales Mgr., (for mail), Atlantic Gypsum Product Co., 40 Rector St., and 49 West 57th St., New York, N. Y.

NEIDECK, Albert August, (Junior 1927), Engr. and Estimator, Peter Sinnott, Htg. Contractor, 621 Tiffany St., and (for mail), 2010 Valentine Ave., Bronx, N. Y.

NEILER, Samuel G., (1898), (for mail), Neiler, Rich & Co., Consulting & Designing Engineer, 431 S. Dearborn St., Chicago, Ill.

NEITZEL, Carl W., (1921), Mgr., The C. W. Neitzel Co., 10724 Hathway Ave., Cleveland, and Belvoir Bldg., S. Euclid, O.

NELSON, Frank, Jr., (1923), Partner, (for mail), Frank Nelson & Son, 1826 Cherry St., and 6349 Greenway Ave., Philadelphia, Pa.

NELSON, George Augustus, (1928), Sales Engr., (for mail), Skinner Bros. Mfg. Co., 949 Broadway, and 2336 University Ave., New York, N. Y.

NELSON, George O., (1923), Engr. and Supt., Carstens Bros., Ackley, Ia.

NELSON, Harold A., (1926), Consulting Engr., 412 Associated Realty Bldg., Los Angeles, and (for mail), 236 S. LaPere Drive, Beverly Hills, Calif.

NELSON, Herman W., (1909), Pres., (for mail), Herman Nelson Corp., 1824 Third Ave., and 2500–11th St., Moline, Ill.

NELSON, Ralph L., (Junior 1913; 1917), Mgr., Heating Assurance, Inc., 507 Empire State Bldg., 3823 Normandie, Spokane, Wash.

NELSON, Richard Herman, (Junior 1928), Production Mgr., Herman Nelson Corp., 1824 Third Ave., Moline, and (for mail), 1632–18th Ave., Longview Apts., No. 3, Rock Island, Ill.

NELSON, Roy O., (Junior 1928), Estimator, Htg. and Vtg., (for mail), The Ensign Engrg. Corp., Rm. 3536, 35 E. Wacker Drive, and 2321 Waveland Ave., Chicago, Ill.

NESBIT, David M.,* (1895), (Board of Governors 1900), Chairman, Ashwell & Nesbit, Ltd., Ashwell Lodge, Barkby Lane, Leicester, Eng.

NESBITT, Albert J.,* (1921), Secy. and Treas., (for mail), John J. Nesbitt, Inc., Holmesburg and Evergreen Rd., Jenkintown Manor, Philadelphia, Pa.

NESBITT, John J., (1923), Pres., (for mail), J. J. Nesbitt, Inc., Holmesburg Junction, Philadelphia, Pa.

NESDAHL, Ellert, (1915), Engr., Carrier Engrg. Corp., 750 Frelinghuysen Ave., Newark, and (for mail), 1453 Concord Place, Elizabeth, N. J.

NESMITH, Earl, (Associate 1928), Engr., Williams Institute Heat Research, Oil-O-Matic Burner Htg. Corp., and (for mail), 107 Warner Ave., Bloomington, Ill.

NEWCOMB, Raymond, 570 Seventh Ave., New York, and (for mail), 20 Hillside Ave., White Plains, N. Y.

NEWPORT, Charles F.,* (1906), Sales Engr., Weil-McLain Co., Michigan City, Ind., and (for mail), 10001 Longwood Drive, Chicago, Ill.

NICELY, John Eyster, (Associate 1925), Vice-Pres. and Sales Mgr., Corbit Bros. Plbg. & Htg. Corp., Inc., 149 N. Fifth St., and (for mail), 1208 Marion St., Reading, Pa.

NICHOLLS, Percy,* (1920), Supervising Engr., Fuel Section, (for mail), U. S. Bureau of Mines, and 273 N. Craig St., Pittsburgh, Pa.

NICHOLS, George B., (1915), (Council 1919-1920), 25 Alden Ave., Colonial Heights, Tuckahoe, N. Y.

NICOL, Norman C., (1923), Engr., National Tube Co., P. O. Box 542, City Hall Sta., N. Y.

NIESTRATH, W. H., Sales Repr., Jas. P. Marsh & Co., 3324 S. Jefferson Ave., St. Louis, Mo.

NILSON, Andrew, (1917), Pres., Eureka Smokeless Furnace Co., 3222 N. Halsted St., and (for mail), 5407 Wayne Ave., Chicago, Ill.

NILSON, Karl A., (Junior 1926), Engr. and Salesman, Nilson Bros., 3222 N. Halsted St., and (for mail), 1463 Summerdale Ave., Chicago, Ill.

NOBBS, Walter W., (1919), 50 Fairhazel Gardens, London, N.W., 6, Eng.

NOBIS, Harry M., (1914), Htg. Engr., 1827 Stanwood Rd., E. Cleveland, O.

NOBLE, Milner, (Junior 1924), (for mail), Aerofin Corp., 750 Frelinghuysen Ave., and 80 Broad St., Newark, N. J.

NOLAND, Lloyd U., (1915), Pres., Noland Co., Inc., Newport News, Va.

NOLAND, Ralph W., (1914), Consulting and Mech. Engr., 332 Utility Bldg., Fort Wayne, Ind.

NOLL, William F., (1924), Asst. Gen. Mgr., The Paul E. Mueller Co., 320 Park St., and (for mail), 1188–48th St., Milwaukee, Wis.

NORDINE, Louis F., (1914), Sales Engr., Herman Nelson Corp., and (for mail), 1170–25th St., Moline, Ill.

NORMAN, Mehrold A., (1926), Htg. Engr., Warren Webster & Co., Rm. 506, 549 W. Washington Blvd., and 4942 Race Ave., Chicago, Ill.

NORRIS, James C., (1928), Mgr., (for mail), The H. B. Smith Co., 49th and Grays Ave., Philadelphia, and 3215 Highland Ave., Drexel Hill, Pa.

NOTTBERG, Henry, (1919), Vice-Pres., (for mail), U. S. Engrg. Co., 914 Campbell St., and 213 S. Bales, Kansas City, Mo.

NOVOTNEY, Thomas A., (1928), Mgr., (for mail), National Radiator Corp., 259 Delaware Ave., and 1240 Delaware Ave., Buffalo, N. Y.

NOYES, George Taft, (1928), Treas. and Engr., The Allen Plumbing Co., 283 Main St., and (for mail), 27 Church St., Presque Isle, Me.

NULSEN, Carl A., (1919), Mgr. Htg. Dept., (for mail), Hanley & Co., 6 N. Clark St., and 931 Ainslie St., Chicago, Ill.

NUSBAUM, Lee,* (1915), Owner, (for mail), Penna. Engrg. Co., 1119 N. Howard St., and 315 Carpenter Lane, Philadelphia, Pa.
NUTTING, Arthur, (Junior 1927), Designing Engr., Reed Air Filter Co., 215 Central Ave., Louisville, Ky.

O

OAKS, Orlon O., (1917), Chief Engr., N. Y. Div., (for mail), American Radiator Co., 40 West 40th St., New York, N. Y., and 13 Russell Place, Summit, N. J.
O'BANNON, Lester Severance,* (1928), Prof. of Heat Engrg., (for mail), University of Kentucky, and 123 State St., Lexington, Ky.
OBERT, Casin W., (1916), Consulting Engr., Union Carbide and Carbon Research Laboratory, Thompson Ave. and Manley St., Long Island City, and (for mail), 122 N. Columbus Ave., Mt. Vernon, N. Y.
O'BRIEN, J. H., (1923), Chicago Dist. Mgr., (for mail), American Blower Co., 228 N. LaSalle St., and 6525 Glenwood St., Chicago, Ill.
O'CONNELL, Edward D., (Associate 1925), Engr., Robt. Scott, Inc., 1512 Vine St., and (for mail), 1432 North 53rd St., Philadelphia, Pa.
O'CONNELL, Michael F.,* (Junior 1927), Engr., Cooling & Air Conditioning Corp., 11 West 42nd St., and (for mail), 1722 Crosby Ave., New York, N. Y.
O'CONNELL, P. M., (Associate 1928), Sales Engr., American Radiator Co., 820 S. Michigan Ave., and (for mail), 7100 N. Robey St., Chicago, Ill.
O'CONNELL, Presly M., (1916), Repr., Hoffman Specialty Co., and (for mail), 5749-31st Ave., N.E., Seattle, Wash.
O'CONNOR, Joseph M., (1923), (for mail), 110 E. Douglas Ave., and 4331 E. English St., Wichita, Kans.
O'DONNELL, Thomas J., (1920), Secy. and Treas., (for mail), William H. McKiever, Inc., 247 West 13th St., New York, and 927 Central Ave., Woodmere, L. I., N. Y.
ODROBINA, Stephen Robert, (1927), Engr., Richardson & Boynton, 260 Fifth Ave., New York, and (for mail), 25-68-35th St., Long Island City, N. Y.
OFFEN, Ben, (1928), Sales Mgr., Chicago Office, The Cooling & Air Conditioning Corp., 30 N. LaSalle St., and East End Park Hotel, Chicago, Ill.
OFFNER, Alfred J., (1922), Consulting Engr., (for mail), 1182 Broadway, New York, and Beechhurst, L. I., N. Y.
OGELSBY, William P., (1923), Sales Mgr., Oil City Boiler Works, 1043 Real Estate Trust Bldg., Philadelphia, Pa.
OLSEN, Carlton F., (Junior 1920; Associate 1925), Service Dept., Kewanee Boiler Co., 822 W. Washington, and (for mail), 6238 Evans Ave., Chicago, Ill.
OLSON, Arvid E., (1925), Engr., Board of Education, 1009 Milton St., and (for mail), 3554 Dickens Ave., Chicago, Ill.
OLSON, Robert G., (1923), Milwaukee Mgr., (for mail), American Blower Co., 1418 Majestic Bldg., and 266 E. Juneau Ave., Milwaukee, Wis.
OLVANY, William J., (1912), Engr. and Contractor, 100 Charles St., New York, N. Y.
O'NEILL, J., (Junior 1925; Associate 1927), Chief Engr., The Trane Co. of Canada, Ltd., 439 King St., W., and (for mail), 8 Springmount Ave., Toronto, Ont., Can.
O'NEILL, Peter, (1920), Treas., Bartley-O'Neill Co., 224 Third Ave., and 2448 Charles St., *Pittsburgh*, Pa.
ORMSBY, H. Kingsley, Jr., (Junior 1928), Salesman, Hoffman Specialty Co., 1538 E. Genesee St., Syracuse, N. Y.
ORR, Fred B., (1924), Asst. to Vice-Pres., (for mail), Illinois Maintenance Co., 72 W. Adams St., and 700 Irving Park Blvd., Chicago, Ill.
ORR, Hugh Ben., (1928), Mgr., York Htg. & Vtg. Corp., (for mail), 1507 First Natl. Bk. Bldg., and 5527 Center Ave., Pittsburgh, Pa.
ORR, Merrill J., (1917) Pres., and Mgr., (for mail), Orr Co., 513 Jackson St., and 1815 Jackson St., Sioux City, Ia.
ORTH, John W., (1919), Pres., Orth Plbg. Co., 509 Columbia St., and 1930 Kossuth, Lafayette, Ind.
OSBORN, Wallace J., (Associate 1927), New York Mgr., Domestic Engineering, 110 East 42nd St., New York, N. Y., and 225 Golden Hill St., Bridgeport, Conn.
OSBORNE, G. H., (1922), Gen. Mgr., (for mail), The Vtg. & Blow Pipe Co., Ltd., 740 Inspector St., and (for mail), 836 Pratt Ave., Outremont, Montreal, Que., Can.
OSBORNE, Maurice M., (1925), Owner, Osborne & Co., 755 Boylston St., and (for mail), 367 Beacon St., Boston, Mass.
OSTRANDER, Lewis F., (1923), Pres., Secy., Engr., O. E. Specialty Mfg. Co., 8 Keefe Ave., and (for mail), 701 Lake Drive, Milwaukee, Wis.
OSWALD, Walter L., (1919), Sales Engr., Crane Co., 23 West 44th St., New York, N. Y., and (for mail), 121 Central Ave., Coldwell, N. J.
OTIS, Gerald E., (1922), Vice-Pres., (for mail), The Herman Nelson Corp., and 1921 23rd Ave., Moline, Ill.
OTT, O. W., (1925), Consulting Mech. Engr., (for mail), 13004 Washington Bldg., and 123 S. Virgil Ave., Los Angeles, Calif.
OTTO, R. W., (1912), Consulting Engr., Toltz, King & Day, Inc., Builders Exchange Bldg., and (for mail), 2147 Carroll Ave., St. Paul, Minn.

P

PADGINTON, George, (1919), Supt. of Htg. and Plbd., Board of Eduaction, 1417 Genessee Bldg., and (for mail), 73 Huntington Ave., Buffalo, N. Y.
PAETZ, Herbert E., (1922), Sales Engr., (for mail), American Blower Co., 2539 Woodward Ave., and 2506 Cadillac Ave., Detroit, Mich.
PAGE, Harry W., (1923), Pres., Wisconsin Equipt. Co., 307 Loan & Trust Bldg., Milwaukee, and (for mail), 119 Warren Ave., Wauwatosa, Wis.
PAINE, Kenneth A., (Junior 1925; Associate 1928), Mgr., Paine Htg. Co., 127 S. State St., and P. O. Box 13, Jackson, Miss.
PAINE, Leonard G., (1920), Philadelphia Mgr., (for mail), C. A. Dunham Co., 200 South 15th St., and 5915 Carpenter St., Philadelphia, Pa.
PAINTER, David H., (Associate 1924), Salesman, Hoffman Specialty Co., and (for mail), 900 East 30th St., Kansas City, Mo.
PARKER, Philip, (1915), Engrg. Dept., Braman Dow & Co., 239 Causeway St., Boston, and (for mail), 8 Middle St., Woburn, Mass.
PARKHILL, David, (1915), Supt., (for mail), The Graff Furnace Co., 116 Wooster St., New York, and 197 Rutland Rd., Brooklyn, N. Y.
PARKS, Vernon H., (1918), Mgr., Meyer Furnace & Supply Co., 1051 St. Louis, Kansas City, Mo., and (for mail), 321 N. Ewing Ave., Dallas, Tex.
PARKS, William N., (Associate 1927), Mgr., Minnesota Br., (for mail), U. S. Radiator Corp., 688 Hampden Ave., St. Paul, and 3436 Pillsbury Ave., Minneapolis, Minn.
PARROTT, Lyle G., (1922), Consulting Engr., McColl, Snyder & McLean, 2348 Penobscot Bldg., and (for mail), 3788 Gladstone Ave., Detroit, Mich.
PARTER, Samuel C., (Junior 1907; 1909), Secy., James H. Merritt & Co., Inc., 207 Water St., and (for mail), 865 West End Ave., New York, N. Y.
PARTLAN, James W., (1916), (for mail), 14290 Goddard Ave., and 2521 Edison Ave., Detroit, Mich.
PATERSON, Frederick C., Jr., (Junior 1928), Htg. and Vtg. Engr., Paterson & Fensel, City Bldg., Bradford, Pa.
PATERSON, G. E., (1926), Owner, (for mail), Paterson Htg. Co., 28 Waugoo St., and 511 Main St., Oshkosh, Wis.
PATERSON, James S., (1922), Mech. Engr. (for mail), Board of Education, 155 College St., and 23 Norton Ave., Toronto, Ont., Can.

PATORNO, Sullivan A. S., (1923), Htg. and Vtg. Engr., (for mail), Meyer, Strong & Jones, Inc., 101 Park Ave., and 1242 Morris Ave., New York, N. Y.
PATTERSON, D. Finley, (Junior 1925), Br. Mgr., Vapor Htg. Co., (for mail), 2129 Cherry St., and 6428 N. Woodstock St., Philadelphia, Pa.
PATTON, Roy Lee, (1927), Vice-Pres., (for mail), Federal Steam Specialty Co., 120 E. Main St., and 1111 West 38th St., Oklahoma City, Okla.
PAULDING, Lewis Grant, (1926), Treas., (for mail), Frank Paulding & Son, Inc., 4736 Grand Central Terminal Bldg., New York, and 8786-116th St., Richmond Hill, N. Y.
PAULSEN, Carl E., (Associate 1926), Archt. Engr., (for mail), Mann & Co., 722 Rorabough-Wiley Blbd., and 511 N. Poplar, Hutchinson, Kan.
PEACOCK, James K., (1921), Sales Engr., (for mail), Hoffman Specialty Co., Inc., 25 West 45th St., New York, and 440 Fowler Ave., Pelham Manor, N. Y.
PEAK, Alexander M., (Junior 1927), Sales Engr., 629 Chestnut St., and (for mail), 5802 N. Fifth St., Philadelphia, Pa.
PEARCE, C. E., (1911), Chief Engr., Guilbert & Betelle, Architects, Chamber of Commerce Bldg., Newark, and (for mail), 1255 Clinton Place, Elizabeth, N. J.
PEASE, Harrison H., (Associate 1922), c/o Carrier Engrg. Corp., 39 Cortlandt St., New York, N. Y.
PECKHAM, Randolph R., (1919), (for mail), 650 Baltimore W., and 3018 Hogarth Ave., Detroit, Mich.
PEEBLES, John K., (Junior 1924; Associate 1925), Peebles & Ferguson, 733 Law Bldg., Norfolk, Va.
PENCE, Millard Davis, (Junior 1927), Htg. Engr., C. A. Dunham Co., 450 E. Ohio St., Chicago, Ill.
PENHALLEGON, R. L., (1925), Mgr., Burnham Boiler Corp. of Calif., 1385 Harrison St., San Francisco, Calif.
PENNELL, S. Howard, (1925), Member of Firm, (for mail), William Macy Stanton, Archt., 1915 Land Title Bldg., Philadelphia, and Hilldale Rd., Lansdowne, Pa.
PENNOCK, William Britton, (1927), Managing Partner, (for mail), Fuel Saving Equipt. & Engrg. Corp., 30 Ferry St., and 733 Quellette Ave., Windsor, Ont., Can.
PENSINGER, Luther C., (Associate 1925), Partner, Burdick Pensinger Co., 3409 East 18th St., and 19 West 42nd St., Kansas City, Mo.
PERHAM, Stanley H., (1920), Consulting Engr., (for mail), Edgecombe & Perham, Illionis Bldg., and 4507 Carrollton Ave., Indianapolis, Ind.
PERKINS, Fred C., (Associate 1923), Treas., (for mail), Perkins-LeNoir Co., 1068 Drexel Bldg., Philadelphia, and Lansdowne, Pa.
PERLSTEIN, Samuel, (Junior 1928), Treas., Frank Perlstein & Son, Inc., 163 S. Bond St., and (for mail), 718 W. State St., Trenton, N. J.
PETERKIN, Stuart MacC., (1922), Engr., C. A. Dunham Co., 229 College St., and (for mail), 71 Deloraine Ave., Toronto, Ont., Can.
PETERMAN, Robert M., (1917), Engr., School Dist., of Philadelphia, 19th St., above Chestnut St., Philadelphia, and (for mail), 205 Lauriston St., Wissahickon, Pa.
PETERS, Harry G., (Associate 1924), Prop., (for mail), Peters Htg. Co., P. O. Box 763, and 638 N. Congress St., Jackson, Miss.
PETERSEN, Gustave, (Associate 1916), Treas. and Mgr., (for mail), Htg. and Vtg. Magazine, 243 West 39th St., New York, and Park Ridge, N. J.
PETHERICK, David H., (Associate 1916), Salesman, U. S. Radiator Corp., 517 Dime Bk. Bldg., Detroit, and (for mail), 9 Kenberton Drive, Pleasant Ridge, Mich.
PFEIFFER, Benjamin J., (Junior 1925), Htg. Contractor, 435 West 41st St., and (for mail), 30 West 112th St., New York, N. Y.
PFEIFFER, J. F., (Junior 1925), Mech. and Htg. Engr., (for mail), Spencer Heater Co., and 346 Louisa St., Williamsport, Pa.
PFUHLER, John L., (Junior 1923; Associate 1925), Plbg. and Htg., 600 Manor Rd., Staten Island, N. Y.
PHELPS, H. R., (Junior 1927), Engrg. Dept., American Blower Corp., 6004 Russell St., and (for mail), 960 Gladstone, Apt. 405, Detroit, Mich.
PHILLIPS, Frank T., (1919), Sales Engr., (for mail), American Radiator Co., 25th and Reed Sts., Philadelphia, Pa., and 827 Belmont Ave., Collingswood, N. J.
PHILLIPS, Frederic W., Jr., (1921), Engr., (for mail), E. W. Mandeville, Inc., 623 Parkside Ave., and 825 East 38th St., Brooklyn, N. Y.
PICKER, F. C., (Associate 1926), Pres., The Air Conditioning & Engrg. Co., 2914 S. Jefferson Ave., and 4568 Tower Grove Place, St. Louis, Mo.
PICKETT, Clinton A., (Associate 1923), Sales Repr., (for mail), Herman Nelson Corp., 200 Rialto Bldg., St. Louis, and 7300 Melrose Ave., University City, Mo.
PIERCE, Edward Franklin, Jr., (Junior 1925), Sales Engr., Hoffman Specialty Co., 72 Lynn Fells Parkway, Melrose, Mass.
PIHLMAN, Arthur A., (1928), Supervisor, (for mail), Consolidated Gas Co., 2 Irving Place, New York, N. Y., and 235 Dwight St., Jersey City, N. J.
PINDER, Percy H., (1919), Treas., (for mail), Standard Steam Specailty Co., 366 Third Ave., New York, N. Y., and 12 Forest Rd., Ridgewood, N. J.
PINES, Sidney, (1920), Asst. Mgr., (for mail), Natkin Engineering Co., 208 Mutual Bldg., and 736 Valentine Rd., Kansas City, Mo.
PIPER, Albert, (1920), Plbg. and Htg. Contracting, (for mail), Piper Bros., 340-346 N. Broad St., Trenton, N. J.
PITCHER, Lester J., (Junior 1924; Associate 1928), Sales Engr., Illinois Engrg. Co., 21st St. and Racine Ave., and 1518 East 69th St., Chicago, Ill.
PITTELKOW, Arthur G., (1907), Pres., Pittelkow Htg. & Engrg. Co., (for mail), 2340 W. Lafayette Blvd., and 225 Covington Drive, Detroit, Mich.
PIZIE, Stuart G., (Associate 1926), Partner, B. J. Pizie & Son, Millbrook, N. Y.
PLACE, Clyde R., (1924), Consulting Engr., (for mail), Grand Central Terminal, and 333 East 57th St., New York, N. Y.
PLACE, Herman R., (1924), Vice-Pres., Sprague, Bates, Place Co., 28 Union St., Boston, and (for mail), 835 Watertown St., W. Newton, Mass.
PLAENERT, Alfred Bernhard, (Junior 1927), Engr., Pharo Htg. Co., 1302 Regent St., and 1114 South Park St., Madison, Wis.
PLASS, Charles Webster, (1928), Partner, (for mail), Plass & Shuttleworth, 1531 Grand Ave., and 426 East 55th St., Kansas City, Mo.
PLAYFAIR, George A., (Associate 1924), Mgr., (for mail), Johnson Temperature Regulating Co., Ltd., 100 Adelaide St., E., and West Hill P. O., Toronto, Ont., Can.
PLEWES, Stanley E., (1917), Philadelphia Mgr., (for mail), Johnson Service Co., 258 S. Van Pelt St., Philadelphia, and Evergreen Rd., Jenkintown, Pa.
PLUNKETT, John H., (1925), Chief of Inspections, Dept. of Public Safety, Bldg. and Boiler Inspection, Rm. 24, State House, Boston, and (for mail), 81 Woodrow Ave., Dorchester, Mass.
POEHNER, Robert E., (1928), Vice-Pres. and Secy., W. H. Johnson & Son Co., 300 E. St. Joe St., and (for mail), 2308 Coyner Ave., Indianapolis, Ind.
POLDERMAN, L. H., (1927), Br. Mgr., Carrier Engrg. Corp., 911 Mateo St., Los Angeles, and 1330 Colorado Blvd., Eagle Rock, Calif.
POOL, Sterling H., (1913), Pres., (for mail), Howard F. Pool Co., 22 Market St., Lynn, and 39 Pinckney St., Boston, Mass.

POOLE, Ernest F., (1921), Engr., (for mail), F. P. Sheldon & Son, 1009 Hospital Trust Bldg., and 74 Farragut Ave., Providence, R. I.

POPE, S. Austin, (1917), Contracting Engr., (for mail), 26 N. Jefferson St., Chicago and 410 Ashland Ave., River Forest, Ill.

POPE, William A., (1906), Contracting Engr., 26 N. Jefferson St., Chicago, and River Forest, Ill.

PORTRUDE, William M., (Junior 1926), Dept. Head, Andersen Meyer & Co., 4-5 Yuen-Ming-Yuen St., and 1458 Ave. Joffre, Shanghai, China.

POSEY, James, (1919), Consulting Engr., (for mail), 201 W. Franklin St., and 4005 Liberty Heights Ave., Baltimore, Md.

POTTINGER, C. T., (1917), Dist. Mgr., American Blower Co., 614-615 Bona Allen Bldg., and 43 Woodcrest Ave., Atlanta, Ga.

POWERS, Fred I., (1920), Salesman, P. O. Box 324, and 605 S. Sixth Ave., Bozeman, Mont.

POWERS, Fred W., (1911), (Council 1918-1919), Pres., (for mail), The Powers Regulator Co., 2720 Greenview Ave., and 900 Castlewood Terrace, Chicago, Ill.

PRATT, Edwin D., (1922), Asst. to Gen. Mgr., Childs Restaurants, 200 Fifth Ave., New York, and (for mail), 283 Glen Ave., Port Chester, N. Y.

PRENTICE, Oliver J., (Associate 1927), Publicity Mgr., (for mail), C. A. Dunham Co., 450 E. Ohio St., and Allerton Club, 701 N. Michigan Ave., Chicago, Ill.

PRESDEE, Cliff W., (Associate 1926), Western Mgr., (for mail), Htg. & Vtg. Magazine, 750 Builders Bldg., Chicago, Ill.

PRICE, William Henry, Jr., (1927), Mgr. New England Office Territory, York Htg. & Vtg. Corp., 46 Cornhill, Rm. 508, Boston, and 15 Heckle St., Wellesley, Mass.

PROBST, A. H., (1919), Sales Engr., (for mail), Morgan-Gerrish Co., 808 LaSalle Ave., Minneapolis, and Minnatonka Beach, Minn.

PROX, Robert F., (Junior 1922; 1923), Vice-Pres., (for mail), Frank Prox Co., P. O. Box 61, and 1608 S. Fourth St., Terre Haute, Ind.

PRYOR, Frederick L., (1913), Advisory, (for mail), National Silk Dyeing Co., 5 Colt St., Paterson, and Towaco, Morris Co., N. J.

PRYOR, Robert W., Jr.,* (1913), (Council 1919-1920), Mech. Engr., (for mail), Kolthan & Pryor, 39 Cortlandt St., New York, N. Y., and 199 Roseville Ave., Newark, N. J.

PURCELL, Arthur J., (1914), Engr., Salesman of Htg. and Vtg. Equipt., 631 New Britain Ave., Hartford, Conn.

PURCELL, Frederick C., (1926), Owner, F. C. Purcell & Co., (for mail), 2847 Grand River Ave., and 2025 Palmer Park Blvd., Detroit, Mich.

PURCELL, Robert E., (1916), Htg., Vtg. and Plbg. Contractor, 1735 Willis Ave., W., and (for mail), 4061 Seebaldt Ave., Detroit, Mich.

PURDY, Alexander K., (1922), Pres., (for mail), Purdy, Mansell, Ltd., 63 Albert St., and 30 Glenrose Ave., Toronto, Ont., Can.

PURDY, Randall B., (Associate 1927), Editorial Staff, "Power," McGraw-Hill Pub. Co., (for mail), Tenth Ave. and 36th St., New York, and 224-05-139th Ave., Laurelton, N. Y.

PURINTON, Dexter J., (Associate 1923), Mech. Engr., (for mail), Voorhees, Gmelin & Walker, 101 Park Ave., New York, N. Y., and Roseville Rd., R. F. D. No. 35, Westport, Conn.

PURSELL, H. E., (1919), Kewanee Boiler Co., and (for mail), 212 S. Tremont St., Kewanee, Ill.

PYLE, John W., (1919), Contractor, (for mail), 30 W. Canal St., and 371 W. Third St., Peru, Ind.

Q

QUALTROUGH, B. F., (Associate 1926), Engr., (for mail), Carbondale Mch. Co., 928 Wyandotte St., and 1411 Forest Ave., Kansas City, Mo.

QUAY, D. M.,* (Charter Member), (Pres. 1909; 2nd Vice-Pres. 1895; 1st Vice-Pres. 1896, 1899), D. M. Quay Co., Builders Exch., and 1352 East 84th St., Cleveland, O.

QUENTIN, Edward H., (Associate 1919), Mgr., (for mail), Johnson Heat Regulating Co., 2328 Locust St., and 3259 Geyer Ave., St. Louis, Mo.

QUIGLEY, William J., (1920), Salesman, (for mail), Gurney Heater Mfg. Co., P. O. Box 184, Buffalo, and 27 Knowlton Ave., Kenmore, N. Y.

QUIRK, Clinton H., (Junior 1915; 1916), Sales Engr., Vtg. Div., (for mail), American Radiator Co., 40 West 40th St., New York, and 36 Kilburn Rd., Garden City, N. Y.

R

RAE, Thos. W., (1924), Salesman, (for mail), American Radiator Co., P. O. Box 882, and James Hotel, Oklahoma City, Okla.

RAINE, John J., (1912), G. S. Blodgett Co., Burlington, Vt.

RAINGER, Wallace F., (Junior 1924), Chief Draftsman, Jaros & Baum, Consulting Engrs., 116 West 39th St., New York, and (for mail), 68 Livingston Ave., Yonkers, N. Y.

RAISLER, Louis, (1925), Raisler Htg. Co., 129 Amsterdam Ave., New York, N. Y.

RAISLER, Samuel, (1921), Pres., Raisler Htg. & Sprinkler Co., 129 Amsterdam Ave., and (for mail), 173 Riverside Drive, New York, N. Y.

RALSTON, Louis T. M., (1926), Consulting Engr., (for mail), 52 Vanderbilt Ave., and 780 Riverside Drive, New York, N. Y.

RAMSEY, Harold Whiteman, (Junior 1928), Secy. and Treas., Standard Htg. Co., Inc., 1705 Alter St., Philadelphia, and (for mail), P. O. Box 31, Newton Square, Pa.

RANDALL, W. Clifton,* (1928), Chief Engr., (for mail), Detroit Steel Products Co., 2250 E. Grand Blvd., and 5540 Ridgewood Ave., Detroit, Mich.

RANDOLPH, Charles H., (Junior 1926), Sales Engr., American Foundry & Furnace Co., Rm. 400, 15 Michigan St., and (for mail), 567 Stowell Ave., Milwaukee, Wis.

RASMUSSEN, Einar, (Junior 1925; Associate 1926), Westinghouse Elec. & Mfg. Co., E. Pittsburgh, and (for mail), 419 Whitney Ave., Wilkinsburg, Pa.

RATHER, Max F., (1919), Mgr., Johnson Service Co., 2142 East 19th St., Cleveland, O.

REARDON, J. Albert, (1921), Pres. and Treas., Reardon Bros. Co., Mfrs. Natl. Bk., 341 Union St., Lynn, and 18 Marion Rd., Marblehead, Mass.

RECH, Philip Doerr, (Associate 1927), Special Repr., Hoffman Specialty Co., Inc., 25 West 45th St., New York, N. Y., and (for mail), 240 E. Ninth St., Plainfield, N. J.

RECK, William Ernst, (1927), Vice-Pres., (for mail), The Reck Htg. Co., Ltd., 15 Esromgade, Copenhagen, and 16 Lundvej, Hellerup, Denmark.

REDERER, Benedict S., (1922), Mgr., (for mail), B. S. Rederer & Co., 513 Arrott Bldg., and 1540 Belasco Ave., Pittsburgh, Pa.

REED, John F., (Associate 1923; 1927), Vice-Pres., (for mail), Reed Air Filter Co., 50 Church St., New York, N. Y.

REED, William M., (1927), Pres., (for mail), Reed Air Filter Co., 215 Central Ave., Louisville, Ky.

REEDER, Charles L., (1911), Consulting Engr., (for mail), 916 N. Charles St., Baltimore, and 222 Longwood Rd., Roland Park, Md.

REESE, Henry L., (1923), Pres. and Gen. Mgr., (for mail), Keystone Plbg. & Htg. Co., 229 N. Sixth St., and 426 Jefferson St., Hyde Park, Reading, Pa.

REHLING, Hugo F., (1928), Dist. Mgr., (for mail), B. F. Sturtevant Co., 913 Provident Bk. Bldg., and 2844 Observatory Ave., Cincinnati, O.

REID, Henry P., (Associate 1927), Specialty Engr., (for mail), Universal Portland Cement Co., Rm. 1520, 210 S. LaSalle St., Chicago, and 3507 Oak Park Ave., Berwyn, Ill.

REILLY, Charles Edward, (Junior 1928), Pres., (for mail), Wynnefield Steam Heat Co., and Bala Steam Heat Co., 4920 City Line Ave., Philadelphia, Pa.

REPP, Harry L., (1922), Sales Repr., (for mail), Herman Nelson Corp., 610 Traction Terminal Bldg., and 525 S. Central Ct., Indianapolis, Ind.

REUSS, Edward H., Jr., (Associate 1919; 1921), Htg. Contractor, (for mail), Edward H. Reuss, Jr., 49th and Grays Ave., Philadelphia, and 220 N. Latch's Lane, Merion, Pa.

REYNOLDS, Henry M., (1915), P. O. Box 350, San Antonio, Tex.

REYNOLDS, Thurlow W., (1922), Engr., American Radiator Co., 40 West 40th St., and (for mail), 1657 Montgomery Ave., New York, N. Y.

REYNOLDS, Walter V., (Associate 1928), Pres., (for mail), Janes-Reynolds Co., Inc., 218 East 52nd St., New York, and 193 Mamaroneck Ave., White Plains, N. Y.

RIBLET, William H., (Associate 1921), 327 Munsey Blvd., Washington, D. C.

RICE, C. J., (Associate 1923), Sales Mgr., (for mail), Modine Mfg. Co., and 2016 Washington Ave., Racine, Wash.

RICE, William W., (1915), Engr., Mellon Co., 4417-19 Ludlow St., Philadelphia, and (for mail), 830 Morgan Ave., Drexel Hill, Del. Co., Pa.

RICHARD, Irenee Talbot, (Associate 1928), Steamfitter and Htg. Engr., 34 Warren St., and (for mail), 10 Carlisle St., Roxbury, Mass.

RICHARDS, S. Frank, (1915), Pres. and Sales Mgr., The Richards Corp., 1125 North Ave., Wilkinsburg Br., and 335 W. Riverview Ave., Bellevue Br., Pittsburgh, Pa.

RICHARDSON, D. Rait,* (1915), Pres., (for mail), Richardson & Boynton Co., 260 Fifth Ave., and 299 Park Ave., New York, N. Y.

RICHARDSON, Frank J., (1921), Mech. Engr., Dept. of Education, Bureau of Plant Operation, 131 Livingston St., and (for mail), 467 First St., Brooklyn, N. Y.

RICHTMANN, William Muir,* (Junior 1926), Test Engr., Bayley Blower Co., 732 Greenbush St., Milwaukee, and (for mail), 765 Wentworth Ave., Milwaukee, Wis.

RICKLY, Francis Andrew, (Associate 1927), Asst. Mgr., (for mail), American Radiator Co., 1008 Pine St., and 5616 Pershing Ave., St. Louis, Mo.

RIETZ, Elmer W., (1923), Asst. Sales Mgr., (for mail), Powers Regulator Co., 2720 Greenview Ave, Chicago, and 940 Glenwood Ave., Winnetka, Ill.

RILEY, Champlain L.,* (1906), (Presidential Member), (Pres. 1921; Council 1918-1922; 1st Vice-Pres. 1920), (for mail), Clark MacMullen & Riley, 101 Park Ave., New York, N. Y., and Plainfield, N. J.

RILEY, DeWitt H., (1921), Engr., American Radiator Co., Bond Plant, 87 Rano St., Buffalo, and (for mail), 88 Columbia Rd., Kenmore, N. Y.

RINKENBERGER, George, (1924), Htg. Engr., (for mail), 224 Market St., and 840 Franklin St., Johnstown, Pa.

RITCHIE, Edmund J., (1923), Gen. Sales Mgr., Sarco Co., Inc., (for mail), 183 Madison Ave., New York, and 19 Grace Ct., Brooklyn, N. Y.

RITCHIE, William, (1909), Vice-Pres., Boynton Furnace Co., 58 West 40th St., New York, N. Y., and (for mail), 17 Van Reipen Ave., Jersey City, N. J.

RITTER, Arthur, (1911), N. Y. Mgr., (for mail), American Blower Co., 50 Church St., New York, and 39 Plaza St., Brooklyn, N. Y.

ROBB, John M.,* (1913), Dir. of Service, The Herman Nelson Corp., Moline, and (for mail), 1513 Columbia Terace, Peoria, Ill.

ROBBINS, Loring G., (1907), Robbins, Gamwell & Co., 68 West St., Pittsfield, Mass.

ROBERTS, Henry L., (1916), Engr. and Contractor, 228 North 16th St., Philadelphia, Pa.

ROBERTS, J. H., (1926), c/o Mrs. E. C. Fell, Upper Lake St., (Carrier No. 19), Elmira, N. Y.

ROBERTSON, John M., (Junior 1926), Sales Engr., (for mail), E. K. Campbell Htg. Co., 4908 Delmar Blvd., and 7321 Zephyr Place, St. Louis, Mo.

ROBINSON, Albert G., (1924), (for mail), 145-49 Warren St., and 18 Harrison Ave., Glen Falls, N. Y.

ROCKART, Edward R., (1921), Mech. Engr., Minneapolis Board of Education, 245 Ninth Ave., N., Minneapolis, and 1173 Arkright St., St. Paul, Minn.

RODMAN, Robert W., (1922), Supt. of Plant Operation, (for mail), Dept. of Education, 500 Park Ave., and 175 West 73rd St., New York, N. Y.

ROEBUCK, William, Jr., (1917), Sales Engr., (for mail), The R. T. Coe Cos., 308 Jackson Bldg., Buffalo, and 1625 East Ave., Rochester, N. Y.

ROEMER, Julius, (1928), Owner, (for mail), J. Roemer Htg. Co., Builders Exchange, Cleveland, and 1478 Bunts Rd., Lakewood, O.

ROGERS, A. Carle, (1921), Consulting Engr., 752 Euclid Ave., Toledo, O.

RONEY, Thomas G., (1916), (for mail), T. G. Roney Htg. Co., 3461 Fort St., W., and 748 25th St., Detroit, Mich.

ROONEY, Martin A.,* (Associate 1917; 1918), Sales Engr., (for mail), American Radiator Co., 374 Delaware Ave., Buffalo, and Eggertsville, N. Y.

ROSEBROUGH, Robert M., (1920), Br. Mgr., (for mail), L. J. Mueller Furnace Co., 4246 Forest Park Blvd., St. Louis, and 7241 Dorset Ave., University City, Mo.

ROSENBACH, Rudolph G., (1920), Sales Engr., (for mail), Warren Webster & Co., 549 W. Washington St., Chicago, and 343 N. York St., Elmhurst, Ill.

ROSENBERG, Philip, (Associate 1928), Pres., Somaron Sheet Metal Works, Inc., 3618 Park Ave., and (for mail), 811 Walton Ave., New York, N. Y.

ROSS, John O., (1920), Pres., (for mail), Ross Industries, Inc., 271 Madison Ave., New York, and Philipse Manor, N. Tarrytown, N. Y.

ROSS, Joseph F., (1926), Secy. and Treas., (for mail), Ross Boiler Co., 112 W. Adams St., and 5608 S. Nagle Ave., Chicago, Ill.

ROSSMAN, Vincent D., (1919), 2365 Klemm St., St. Louis, Mo.

ROTHROCK, John T., (1920), Supt. Mech. Engr., Thompson-Starrett Co., Packard Bldg., Philadelphia, Pa.

ROTTMAYER, Samuel I., (Junior 1928), Engr., Samuel R. Lewis, Consulting Engr., 407 S. Dearborn St., and (for mail), 918 Winona Ave., Chicago, Ill.

ROTZ, John M., (1918), Engr., (for mail), J. M. Rotz Engrg. Co., 704 Merchants Bk. Bldg., Indianapolis, and Carmel, Ind.

ROWE, William A., (1921), Chief Engr., American Blower Co., 6004 Russell St., and 1733 Virginia Park, Detroit, Mich.

ROWLEY, Frank Benj.,* (1918), Prof. of Mech. Engrg. and Dir. of Experimental Engrg. Laboratories, University of Minnesota, and (for mail), 63 Barton Ave., S.E., Minneapolis, Minn.

ROYER, Earl B., (1928), Designing Engr., Fosdick & Hilmer, Consulting Engrs., 1703 Union Trust Bldg., and (for mail), 6635 Iris Ave., Kennedy Heights, Cincinnati, O.

RUCKEL, John B., (Associate 1919), Pres., (for mail), J. H. Ruckel & Son, 81-83 Main St., and 183 Cleveland Ave., Buffalo, N. Y.

RUDDELL, Wm. H., (1921), Mgr., (for mail), West Coast Htg. Co., Inc., 505 Lloyd Bldg., Sixth Ave., and Stewart St., and 816 W. Blaine St., Seattle, Wash.

RUFF, DeWitt C., (1922), Treas., (for mail), Healy-Ruff Co., 765 Hampden Ave., and 2211 St. Clair St., St. Paul, Minn.

RUGART, Karl F. K., (Associate 1924), Sales Engr., (for mail), Warren Webster & Co., Camden, N. J., and 5830 Willows Ave., W. Philadelphia, Pa.

RUGGLES, Robert F., (Junior 1926), Asst. Sales Mgr., DeBothezat Impeller Co., 1922 Park Ave., New York, and (for mail), 15 Gregg Place, Randall Manor, Tompkinsville, S. I., N. Y.

RUPPERT, E. H., (Associate 1923), (for mail), Excelso Specialty Works, 210 East 45th St., New York, and (for mail), 85 Eastern Parkway, Brooklyn, N. Y.

RUSSELL, Edward A., (Associate 1927), Mech. Asst. to Pres., Vapor Car Htg. Co., 1450 Railway Exchange Bldg., and (for mail), 8103 Dorchester Ave., Grand Crossing Station, Chicago, Ill.

RUSSELL, Hugh C., (1911), Inspector, Mech. and Elec. Engr., (for mail), U. S. Treasury Dept., 215 Post Office Bldg., and 909 E. Tenth St., Chattanooga, Tenn.

RUSSELL, Joseph N., (1899), Mgr., Rosser & Russell, Ltd., 37 Duke St., Oxford St., London, W. 1., Eng.

RUSSELL, W. A., (1921), Asst. Gen. Sales Mgr., (for mail), U. S. Radiator Corp., 3254 N. Kilbourn, Chicago, Ill., and 2484 Pingree, Detroit, Mich.

RUSSELL, William Arthur, (Charter Member), Pres., W. A. Russell & Co., 5037 Grand Central Terminal Bldg., New York, N. Y.

RUSSELL, William Bradford, (1928), Works Mgr., Heggie Simplex Boiler Co., and (for mail), R. F. D. No. 1, Joliet, Ill.

RUSSELL, William L. A., (Associate 1925), St. Louis Sales Mgr., (for mail), Skinner Bros. Mfg. Co., 1474 S. Vandeventer St., and 1246 Temple Place, St. Louis, Mo.

RYAN, Harry J., (1922), Consulting Engr., 47 Harris Ave., Albany, N. Y.

RYDELL, Carl A., (Junior 1928), Htg. and Vtg. Engr., Meyer, Strong & Jones, Inc., 101 Park Ave., and (for mail), 414 East 204th St., New York, N. Y.

RYEN, Max, (Junior 1928), Engr., (for mail), Pierce, Butler & Pierce Mfg. Corp., Eastwood Plant, and 304 Van Buren St., Syracuse, N. Y.

S

SABIN, Edward R., (1919), Pres., (for mail), Edward R. Sabin Co., Htg. Contractors., 4710-12 Market St., Philadelphia, and Lansdowne, Pa.

SACHLEBEN, Edward H., (Associate 1921), (for mail), E. H. Sachleben & Co., 2829 Locust St., St. Louis, Mo.

SADLER, Charles Boone, (1928), Design Draftsman, (for mail), Public Works Office, 11th Naval Dist., and 1723 Granada Ave., San Diego, Calif.

ST. CLAIR, Charles W., (Junior 1927), Sales Engr., (for mail), Herman Nelson Corp., Rm. 321, 1836 Euclid Ave., Cleveland, and 12053 Lake Ave., Cleveland, O.

ST. JOHN, Joseph S., (Junior 1928), Chief Engr., (for mail), Agree-Garelik Co., 99 E. Baltimore St., and Northern Br. Y. M. C. A., Detroit, Mich.

SAKOUTA, Mathieu L., (1924), Consulting Engr. Expert, Gavan, Simanskaia 4, Leningrad, Russia.

SAMUELS, Sidney, (Junior 1925; Associate 1928), Secy., (for mail), Paramount Plbg. & Htg. Supply Corp., 262 West 145th St., and 626 West 165th St., New York, N. Y.

SANBERN, E. Nute,* (1923), Engr., (for mail), *Mensing* & Co., 928 Presser Bldg., Philadelphia, Pa., and 119 Haviland Ave., Audubon, N. J.

SANBORN, Stephen H., (Associate 1924), S. H. Sanborn Engrg. Co., 123 E. Main St., P. O. Box 289, Middletown, N. Y.

SANFORD, Arthur L., (1915), Mech. Engr., (for mail), Board of Education, 245 Ninth Ave., N., and 301 East 48th St., Minneapolis, Minn.

SAULSON, Saul, (1916), Mech. Engr., Albert Kahn, Inc., 1000 Marquette Bldg., and 2491 W. Euclid, Detroit, Mich.

SAUNDERS, J. Chester, (1926), Estimator and Engr., (for mail), Crosby & Beard Co., 163 W. Harrison St., and 10921 Oakley Ave., Chicago, Ill.

SAVILLE, Thos. H., (1924), (for mail), 2009 N. Wabash Ave., and 1121 Lafayette St., Scranton, Pa.

SAWADE, Carl A., (Associate 1920), National Radiator Corp., 15th Floor, 55 West 42nd St., New York, N. Y.

SAWDON, Will M., (1920), Prof. Exper. Engrg., (for mail), Cornell Univ., and 1018 E. State St., Ithaca, N. Y.

SCHANK, George E., (Associate 1926), 155 16th St., Buffalo, N. Y.

SCHANZE, A. Gale, (Associate 1925), Gen. Mgr., Hardinge Oil Burner Corp., 843 Beacon St., Boston, and (for mail), 30 Willoughby St., Brighton, Mass.

SCHEER, Frederick W., (1922), Htg. Contractor, (for mail), 430 Connecticut, and 12 Brayton St., Buffalo, N. Y.

SCHEIBEL, Albert H., (1919), Designing Engr., Stone & Webster, 49 Federal St., Boston, and (for mail), 92 Milton Ave., Hyde Park, Mass.

SCHEIDECKER, Daniel B., (Associate 1919), Secy., (for mail), Hunter-Clark Vent. System Co., 2800 Cottage Grove Ave., and 4626 N. Kilbourn Ave., Chicago, Ill.

SCHELLHAMMER, Alfred L., (1919), Mgr., Pennsylvania Furnace & Iron Co., Warren, Pa.

SCHILDMILLER, George H., (1922), 55 W. Huron St., Pontiac, Mich.

SCHIMMEL, F. W., (1926), Resident Engr., Warren Webster & Co., 279 Cumberland St., Harrisburg, Pa.

SCHLEY, Arthur A., (1920), Mgr., Htg. Dept., Schley & Nash Co., 709 Columbia Bk. Bldg., Pittsburgh, Pa.

SCHLOSS, Newton L., (1913), (for mail), Engrg. Service, 51 East 42nd St., and Hotel Lincoln, New York, N. Y.

SCHMIDT, George G., (Junior 1912; 1914), Gen. Eastern Repr., Carrier Engrg. Corp., 39 Cortlandt St., New York, and 55 Burns St., Forest Hills, Long Island, N. Y.

SCHNEIDER, Charles, (1923), Pres., (for mail), C. Schneider Co., 492 East 163rd St., and 2178 University Ave., New York, N. Y.

SCHNEIDER, Paul W., (1919), Pres., (for mail), P. W. Schneider, Inc., 307 Lafayette St., and 2039 Genesee St., Utica, N. Y.

SCHOENIJAHN, Robert P., (1919), Consulting Engr., (for mail), 406 Industrial Trust Bldg., and 719 Nottingham Rd., Wilmington, Del.

SCHOEPFLIN, Paul H., (1920), Pres., (for mail), Niagara Blower Co., 95 Liberty St., New York, N. Y.

SCHOFIELD, Thomas Johnson, (1928), Gen. Mgr., Schoefield-Cowl Co., 23 Tenth St., and Glenwood Heights, Wheeling, W. Va.

SCHOPP, Walter J., (1922), Partner, (for mail), General Engrg. & Construction Co., 923 Garfield Ave., Palmyra, N. J., and 1704 Ludlow St., Philadelphia, Pa.

SCHRADER, C. C.,* (Junior 1923; Associate 1925), Research Engr., (for mail), Armstrong Cork Co., Research Division, Lancaster, Pa.

SCHRAM, Waldo W., (1928), Supervision House-Heating Div., Northern Indiana Public Service Co., (for mail), 649 Hohman St., and 132 Vine St., Hammond, Ind.

SCHROTH, August H., (1911), Vice-Pres., Richmond Radiator Co., 1480 Broadway, New York, N. Y., and (for mail), 90 S. Oraton Parkway., E. Orange, N.J.

SCHUKAI, Walter C., (Junior 1928), Estimator, (for mail), Eichler Heating Co., 2010 Railway Exchange Bldg., and 2622 North 19th St., St. Louis, Mo.

SCHULZ, Howard I., (Associate 1915), Mgr., Crane Co., (for mail), 1223 W. Broad St., and 1535 West Ave., Richmond, Va.

SCHULZE, Ben. H., (1921), Sales Engr., (for mail), Hester-Bradley Co., 4200 Forest Park Blvd., and 1914 Forest Ave., St. Louis, Mo.

SCHWAB, Henry E., (1923), Vice-Pres., (for mail), R. J. Schwab & Sons Co., 283 Clinton St., and 671 Franklin Place, Milwaukee, Wis.

SCHWAB, Quentin D., (Junior 1927), Htg. Engr., (for mail), Henschien & McLaren, 1637 Prairie Ave., and 2017 Prairie Ave., Chicago, Ill.

SCHWEIM, Henry J., (1928), Development Engr., (for mail), U. S. Gypsum Co., 300 W. Adams St., Chicago, and 2233 Forest View Rd., Evanston, Ill.

SCOLLAY, Ulysses G., (Charter Member), (Council 1894; Board of Managers 1895; Treas. 1904; 1911), Pres., J. A. Scollay, Inc., 308 Halsey St., Brooklyn, N. Y.

SCOTT, Charles E., (1907), Pres. and Treas., (for mail), Vapor Engineering Co., 489 Fifth Ave., New York, N. Y., and Meadowbrook Rd., Darien, Conn.

SCOTT, Clarence Earl, (Junior 1926), Research Engr., (for mail), York Htg. & Vtg. Corp., York Bldg., 16th and Sansom St., Philadelphia, and 611 Sinede St., Norristown, Pa.

SCOTT, Edwin A., (1912), Pres. and Treas., (for mail), Edwin A. Scott Publishing Co., 45 West 45th St., and 3224 Grand Concourse, New York, N. Y.

SCOTT, George M., (1915), Vice-Pres., Child & Scott Co., 108 Wooster St., New York, and 319 Glen Ave., Port Chester, N. Y.

SEELIG, Alfred E., (1926), Pres. and Gen. Mgr., L. J. Wing Mfg. Co., 154 West 14th St., and (for mail), 310 Convent Ave., New York, N. Y.

SEELIG, Lester, (1925), Mech. Engr., Drying Systems, Inc., 1807 Foster Ave., and 2630 N. Spaulding Ave., Chicago, Ill.

SEIDERS, John T., (1926), Htg. and Vtg. Engr., (for mail), Rm. 219, 83½ S. High St., and 980½ N. High St., Columbus, O.

SEITER, J. Earl, (1928), Htg. Repr., Consolidated Gas, Elec. Lt. & Power Co., Lexington Bldg., Baltimore, and (for mail), 21 Florida Rd., Towson, Md.

SEKIDO, Kunisuke, (1903), Nakano, Tokio Suburb, Japan.

SELIG, Ernest T., (1926), Consulting Htg. Engr., (for mail), 1501 Herr St., and 920 North 16th St., Harrisburg, Pa.

SELLARS, Fred J., (1917), Pres., (for mail), Sell-Orr Heating Co., 311 N. Penn Ave., and 619 N. Ninth St., Independence, Kan.

SELLMAN, Niles T., (1922), Asst. to Vice-Pres. and Asst. Secy., in Charge of Sales and Utilization, Consolidated Gas Co., of N. Y. (for mail), 130 East 15th St., and 135 West 183rd St., New York, N. Y.

SELTZER, A. P., (1921), Show Rm. Mgr., (for mail), American Radiator Co., 820 S. Michigan Ave., Chicago, and Evanshire Hotel, Evanston, Ill.

SENIOR, Richard L., (1925), Engr. and Supt., J. Gescheidt & Co., Inc., 142 East 43rd St., New York, and (for mail), 1 Edgewater Place, Dillon Park, New Rochelle, N. Y.

SETZER, Walter C., (Junior 1922 Associate 1926), Archt.'s Repr., Pierce, Butler & Pierce Mfg. Co., 31st and Oxford Sts., (for mail), 211 Gillham St., Lawndale, Philadelphia, Pa.

SEWARD, Percival H.,* (Charter Member), Vice-Pres., Richmond Radiator Co., 1480 Broadway, New York, and (for mail), 369 Washington Ave., Brooklyn, N. Y.

SEWELL, John M., (1919), Consulting Engr., (for mail), 14 South 20th St., Philadelphia, and Berwyn, Pa.

SHANKLIN, John Andrew, (1928), Estimator, (for mail), West Virginia Htg. & Plbg. Co., 233 Hale St., and 5 Swarthmore Ave., Charleston, W. Va.

SHANKLIN, John R., (1899), Htg. Engr., (for mail), W. Va. Htg. & Plbg. Co., 233 Hale St., and 1507 Quarrier St., Charleston, W. Va.

SHAW, Edgar, (1923), Pres., Lynch & Woodward, Inc., 320 Dover St., Boston, and 51 Royal St., Wollaston, Mass.

SHAW, N. J. H., (Junior 1925), Sales Engr., Barnes & Jones, 5 Melrose St., Boston, and (for mail), 99 Melrose St., Arlington, Mass.

SHAW, Raymond E., (1921), Sales Mgr., (for mail), B. F. Sturtevant Co., Hyde Park, Boston, Mass.

SHAY, Russell A., (1924), Htg. Engr., 108 Linwood St., Brooklyn, N. Y.

SHEARS, Matthew W., (1922), Htg. Engr., C. A. Dunham Co., Ltd., 1523 Davenport Rd., and (for mail), 53 Sylvan Ave., Toronto, Ont., Can.

SHEFFIELD, Edward B., (1921), Sales Engr., (for mail), Armstrong Cork Co., 11 Brant St., Toronto, and Lambton Mills, Ontario, Can.

SHEFFLER, Morris, (1921), Member of Firm, (for mail), Sheffler-Gross Co., 205-211 Drexel Bldg., and 5451 Lebanon Ave., Philadelphia, Pa.

SHELDON, Nelson Edward, (1927), Dist. Sales Mgr., (for mail), York Htg. & Vtg. Corp., 703 Temple Bldg., and 942 Genesee Park Blvd., Rochester, N. Y.

SHEPPARD, Frank A., (1918), Kansas City Mgr., (for mail), Johnson Service Co., 411 E. Tenth St., and 4550 Mill Creek Blvd., Kansas City, Mo.

SHEPPARD, William G., (1922), Partner, (for mail), Sheppard & Abbott, Harbourd St., and 479 Dovercourt Rd., Toronto, Ont., Can.

SHEPSTONE, Oscar, (1927), Mech. Engr., Detroit Edison Co., 2000 Second Ave., and (for mail), 121 N. Phillip Ave., Detroit, Mich.

SHERET, Andrew, (Associate 1925), Pres., (for mail), Andrew Sheret, Ltd., 1114 Blanchard St., and 1030 St. Charles St., Victoria, B. C.

SHERIFFS, Walter A., (1918), Mehring & Hanson Co., 162 N. Clinton St., Chicago, Ill.

SHERRY, Raymond Wilbur, (1927), Estimator and Engr., C. H. Sherry, 349 W. Broad St., and (for mail), 601 Peace St., Hazelton, Pa.

SHINOHARA, Shiro, (1924), Master, Shinohara & Co., 14th Bldg., Marunouchi, and (for mail), 2 Chome Kojimachi Kojimachikes, Tokio, Japan.

SHIPP, C. C., (1923), Owner, (for mail), C. C. Shipp & Co., 230 E. Ohio St., and 3405 Guilford Ave., Indianapolis, Ind.

SHODRON, John G., (1921), Research Engr., James Mfg. Co., 411 E. Milwaukee Ave., Ft. Atkinson, Wis.

SHORB, Will A., (1909), Treas., Field & Shorb Co., 133 W. William St., and (for mail), 3 Lincoln Place, Decatur, Ill.

SHOZO, Saito, (1923), Htg. and Vtg. Engr. and Contractor, (for mail), Marunouchi Bldg., and 171 Kitakamata, Tokio, Japan.

SHREINER, Dewey C., (Junior 1923; Associate 1926), Vice-Pres. and Treas., Shreiner & Son, Inc., (for mail), 116 W. High St., and 1240 Southern Blvd., Elkhart, Ind.

SHROCK, John H., (1924), Vice-Pres., (for mail), New York Blower Co., and 109 Franklin St., LaPorte, Ind.

SHRUM, A. T., (1928), Pres., (for mail), Mechanical Equipt. Co., 305 Louisville Trust Bldg., and 41 E. Weissinger-Gaulbert Apt., Louisville, Ky.

SHUELL, Frank W., (Associate 1921), Pres. and Gen. Mgr., (for mail), Ever Hot Heater Co., 5241 Wesson Ave., Detroit, and Lone Pine Rd. Birmingham, Mich.

SHUFELT, Howard M., (Associate 1928), Research and Production Div., Duro Air Filter Co., 3155 Shields Ave., and (for mail), 7353 Bennett Ave., Chicago, Ill.

SHULTZ, Earle, (Associate 1919), Vice-Pres., (for mail), Illinois Maintenance Co., 72 Edison Bldg., and 1310 Birchwood Ave., Chicago, Ill.

SIEBS, Claude T., (Associate 1927), Factory Planning Engr., Western Elec. Co., 100 Central Ave., Kearny, N. J.

SIEGEL, Leo, (Junior 1924; Associate 1925), Mech. Engr., Board of Education, Bridge and Concord Sts., and (for mail), 1909 Stillwell Ave., Brooklyn, N. Y.

SIMPSON, William A., (1925), Engr., (for mail), Johnson & Morris, 538 West 23rd St., and 1269 Grand Concourse, New York, N. Y.

SIMPSON, William K., (1919), Secy., (for mail), Hoffman Specialty Co., 193 Grand St., and 9 Sands St., Waterbury, Conn.

SKAGERBERG, R., (Junior 1921; 1924), Consulting Engr., 1497 Chelmsford Ave., St. Paul, Minn.

SKELLY, John F., (1921), Htg. Contractor, J. F. Skelly, 303 Catherine St., Ogdensburg, N. Y.

SKINNER, Henry W., (1920), Mech. Engr., (for mail), W. C. Hedrick, Archt., 1005 First Natl. Bk. Bldg., and 1300 Dorothy Lane, Ft. Worth, Tex.

SKLENARIK, Louis, (Junior 1928), Htg. and Vtg. Engr., (for mail), Thompson-Starrett Co., 245 Hunters Point Ave., Long Island City, and 305 East 72nd St., New York, N. Y.

SLADE, Arthur J., (Associate 1925), Dir. of Sales, (for mail), American District Steam Co., and Louise St., N. Tonawanda, N. Y.

SLIGHT, Irvin, (Junior 1925; Associate 1926), Slight Bros., Willow Grove, and Hartsville, Pa.

SMALL, John D., (1910), Consulting Engr., (for mail), 127 N. Dearborn St., Chicago, and 411 Maple Ave., Wilmette, Ill.

SMALLMAN, Edwin W., (1920), Engr., Stone & Webster, Inc., 49 Federal St., Boston, and (for mail), 87 Essex St., Melrose, Mass.

SMALLMAN, William T., (1911), Treas., (for mail), Isaac Coffin Co., 52 Sudbury St., Boston, and 127 Rockland Ave., Malden, Mass.

SMITH, Gard Wentworth, (1927), Mgr., Furnace Dept., Jewel Div., (for mail), Detroit Stove Works, 6900 E. Jefferson Ave., and 2133 Montclair Ave., Detroit, Mich.

SMITH, Harold Paul, (1928), Mgr., The H. B. Smith Co., De Normandie Ave., Fair Haven, N. J.

SMITH, John Colbourne, (Junior 1927), Sales Engr., Niagara Blower Co., 673 Ontario St., Buffalo, and (for mail), 95 Columbia Blvd., Kensmore, N. Y.

SMITH, Leslie L., (1919), Chief Mech. and Elec. Engr., (for mail), Smith, Hinchman & Grylls, 800 Marquette Bldg., and 17305 Lilac Ave., Detroit, Mich.

SMITH, Milton S., (1919), Production Mgr., Carrier Engrg. Corp., 750 Frelinghuysen Ave., Newark, and (for mail), 13 North Terrace, Maplewood, N. J.

SMITH, Philip C., Jr., (1928), Specialty Engr., The H. B. Smith Co., 49th St. and Grays Ave., Philadelphia, Pa., and (for mail), Northport, L. I.

SMITH, Sidney S., (1926), Vice-Pres., (for mail), Andes Range & Furnace Corp., Geneva, N. Y.

SMITH, Virgil A., (Junior 1923), Sales Engr., (for mail), C. A. Dunham Co., 2304 Cleveland Ave., Tampa, Fla.

SNELL, Ernest, (1920), Htg. and Vtg. Engr., 3914 LeMay Ave., Detroit, Mich.

SNIDER, L. A., (1927), Pres., (for mail), L. A. Snider Engrg. Service, Inc., 612 N. Michigan Ave., Chicago, Ill.

SNYDER, Charles B. J., (1895), (Presidential Member), (Board of Governors 1900-1904; 2nd Vice-Pres. 1905; 1st Vice-Pres. 1906; Pres. 1907; Board of Governors 1908), 183 Madison Ave., New York, N. Y.

SNYDER, Jay W., (1917), Member of Firm, (for mail), McColl, Snyder & McLean, 2348 Penobscot Bldg., and 8987 Martindale Ave., Detroit, Mich.

SNYDER, Joseph S., (Assoicate 1925), Spec. Repr., (for mail), American Radiator Co., 374 Delaware Ave., and 39 Granger Place, Buffalo, N. Y.

SODEMANN, Paul W., (Junior 1920; Associate 1925; 1926), Dist. Repr., Aerofin Corp., and (for mail), 4947 Cote Brilliante Ave., St. Louis, Mo.

SODEMANN, William C. B., (1919), Pres., Sodemann Htg. & Power Co., 2300 Morgan St., and 3510 University St., St. Louis, Mo.

SODERBERG, Charles H., (1919), Consulting Engr., (for mail), 608 Donovan Bldg., Detroit, and 220 Puritan Rd., Birmingham, Mich.

SOMERS, William Stuart, (Junior 1926), Supt., Success Heater Mfg. Co., 1015 Murphy St., and (for mail), 2807 Grand Ave., Des Moines, Ia.

SOMMER, Louis J., Jr., (1922), Pres., Louis J. Sommer & Son, 2436 Brown St., and 4809 Chestnut St., Philadelphia, Pa.

SOPER, Horace A., (1916), Vice-Pres., (for mail), American Foundry & Furnace Co., and 1122 E. Monroe St., Bloomington, Ill.

SOPER, Ira N., (1919), Sales Engr., (for mail), Warren Webster & Co., 549 W. Washington St., and 6915 Harper Ave., Chicago, Ill.

SOULE, Lawrence C., (1908), Secy., and Sales Mgr., Aerofin Corp., 750 Frelinghuysen Ave., Newark, and 26 Wooton Rd., Essex Fells, N. J.

SOWERS, Paul E., (1922), Gen. Mgr., (for mail), Paul E. Sowers Co., Htg. and Vtg. Engrs., 25 N. Duke St., and 110 Findley St., York, Pa.

SPAFFORD, Allen, (Associate 1927), Chief Engr., Wood Conversion Co., and (for mail), 406 Avenue D, Cloquet, Minn.

SPECKMAN, Charles H., (1918), Htg. Engr., 375 Bourse Bldg., Philadelphia, Pa.

SPELLER, Frank N.,* (1908), Dir., Dept. of Metallurgy and Research, (for mail), National Tube Co., 1810 Frick Bldg., and 6411 Darlington Rd., Pittsburgh, Pa.

SPERZEL, Henry J., (Associate 1918; 1919), N. W. Br. Mgr., Kewanee Boiler Co., 708 Builders Exch., and 4644 Bryant Ave., S., Minneapolis, Minn.

SPIELMAN, Gordon P., (Junior 1923), Vice-Pres. and Secy., (for mail), Harrison-Spielman Co., 480 Milwaukee Ave., Chicago, and 515 N. Prospect Ave., Park Ridge, Ill.

SPITZLEY, Ray L., (1920), Pres., L. Spitzley Htg. Co., 1200 W. Fort St., Detroit, Mich.

SPOONER, Harold R., (1921), Engr. and Estimator, Atlas Heating Co., Inc., Butler Bldg., Jamica Ave. and 159th St., Jamaica, and 190-02 Woodhull Ave., Hollis, N. Y.

SPRAGUE, Frank H., (1923), Secy., (for mail), Skidmore Corp., 1535 Dayton St., Chicago, and 1522 Forest Ave., Wilmette, Ill.

SPROULL, Howard E., (1920), Dist. Mgr., American Blower Co., 905 Sycamore St., and 3588 Raymar Drive, Hyde Park, Cincinnati, O.

SPURGEON, Joseph H., (1924), Sales Engr., (for mail), Joseph H. Spurgeon Co., 3-224 Gen. Motors Bldg., and 818 Woodmere Ave., Detroit, Mich.

STACEY, Alfred E., Jr.,* (1914), Research Engr., Carrier Engrg. Corp., 750 Frelinghuysen Ave., Newark, and (for mail), Wootton Rd., Essex Fells, N. J.

STACK, Murle F., (Associate 1925), Vice-Pres., (for mail), Sunkel Appliance Corp., 308 N. Newstead, St. Louis, Mo.

STACKHOUSE, Raymond M., (Associate 1908; 1919), (for mail), 1294 East 55th St., and 2040 Stearns Rd., Cleveland, O.

STAMMER, Edward L.,* (1919), Supt., Htg. and 506 Locust St., and 4430 Tennessee Ave., St. Louis, Mo.

STANFORD, Leland E., (1921), Mgr., Forbs-Stanford Co., 756 Upson St., Akron, and (for mail), 445 Hudson Rd., R. F. D. No. 3, Kent, O.

STANGER, Ralph B., (1920), Mgr., (for mail), Robinson & Stanger, 917 Empire Bldg., and 728 E. End Ave., Pittsburgh, Pa.

STANGLAND, B. F., (Charter Member), (Board of Managers 1895; 1899, Council 1896; 1897; Board of Governors 1905; 1906; 1909; 2nd Vice-Pres. 1908), Morton, N. Y.

STANNARD, James M.,* (1906), (Board of Governors 1913; Council 1914, 1917), Pres., (for mail), Stannard Power Equipment Co., 926 Monadnock Block, Chicago, and 1402 Elinor Place, Evanston, Ill.

STANTON, Gerard William, (1928), Pres., (for mail), Almirall & Co., Inc., 53 Park Place, New York, N. Y., and 231 Washington Place, Hasbrouck Heights, N. J.

STAPLES, William H., (Associate 1924), Gillis & Geoghegan, 537 W. Broadway, and 137 West 96th St., New York, N. Y.

STARK, W. Elliott,* (1926), Res. Engr., Bryant Heater & Mfg. Co., 17825 St. Clair Ave., Cleveland, and (for mail), 1849 Windermere Ave., E. Cleveland, O.

STARKS, Verne E., (1921), Dist. Mgr., (for mail), Ilg Elec. Vtg. Co., 1314 Schofield Bldg., and 13488 Clifton Blvd., Cleveland, O.

STEARNS, Walter I., (Associate 1926), Owner, (for mail), 560 North 16th St., and 1009 South 46th St., Philadelphia, Pa.

STECKHAN, Louis, (Junior 1926), Estimator, (for mail), Crane Co., 30 South 16th St., and 3014 Indiana Ave., St. Louis, Mo.

STEDMAN, Charles N., (1921), Dist. Sales Mgr., (for mail), C. N. Stedman Co., 610 Wrigley Bldg., and 6917 Crandon Ave., Chicago, Ill.

STEIM, Charles J., Jr., (1923), Mgr. Br. Sales Office, (for mail), C. A. Dunham Co., 91 State St., and 3 Elk St., Albany, N. Y.

STEINHORST, Theodore F., (1919), Supt. and Treas., (for mail), Emil Steinhorst & Sons, 1158 Mohawk St., and West Shore R. R., and 1664 Brickerhoff Ave., Utica, N. Y.

STEINKE, G. B., (1924), Pres., (for mail), 103 Park Ave., New York, and 2730 Decatur Ave., Brooklyn, N. Y.

STEINMULLER, J. M., (1925), Mech. Engr., (for mail), Thompson-Starrett Co., 245 Hunters Point Ave., Long Island City, and Lake Mohopac, N. Y.

STEPHEN, Harold M., (Associate 1926), James E. Degan Co., 622 First St., and 3729 Clements Ave., Detroit, Mich.

STEPHENSON, Lewis A., (1917), Mgr., (for mail), Powers Regulator Co., 409 East 13th St., and 801 West 57th St., Kansas City, Mo.

STERN, H. R., (1923), (for mail), Johnson & Morris, 538 West 23rd St., and 225 West 86th St., New York, N. Y.

STERNBERG, I. C., (1926), Chief Engr., (for mail), Arctic Nu-Air Corp., 110 East 42nd St., and 1271 Morris Ave., New York, N. Y.

STETSON, Lawrence R., (1913), Engr., (for mail), Engr., The McMurrer Co., 303 Congress St., Boston, and 35 Bradfield Ave., Roslindale, Mass.

STEVENS, Frank H., (Associate 1924), Sales Engr., (for mail), Pacific Steel Boiler Corp., and 570 Western Ave., Albany, N. Y.

STEVENS, Harry L., (Junior 1924), Member of Firm, (for mail), M. M. Stevens Co., 108 W. Sherman St., and 7 West 22nd St., Hutchinson, Kan.

STEVENSON, Wilbur W., (1928), Steam Htg. Engr., Allegheny Co., Steam Htg. Co., (for mail), 436 Lancaster Ave., and 1125 Lancaster Ave., Pittsburgh, Pa.

STEWART, C. W., (Associate 1918; 1919), Asst. Sales Mgr., Hoffman Specialty Co., Inc., 25 West 45th St., and (for mail), Apt. 2 F, 644 Riverside Drive., New York, N. Y.

STILES, Harry Leroy, (1928), Mech. Engr., (for mail), Edison Electric Appliance Co., 5660 W. Tayler St., and 5844 W. Lake St., Chicago, Ill.

STILL, Fred R.,* (1904), (Presidential Member), (Pres. 1918; 2nd Vice-Pres. 1917; Council 1916-1919), Vice-Pres. in charge of Export, (for mail), American Blower Co., 30 Church St., and 895 West End Ave., New York, N. Y.

STITT, Eugene W., (1917), Htg. Supervisor, (for mail), Standard Sanitary Mfg. Co., 213 Galveston Ave., Pittsburgh, and 1535 Park Blvd., Dormont, Pittsburgh, Pa.

STITT, Howard B., (Associate 1922), Salesman, (for mail), National Radiator Corp., 431 W. Georgia St., and 506 West 29th St., Indianapolis, Ind.

STOCK, Edward L., (Associate 1918), Pres., (for mail), Niagara Radiator & Boiler Co., 1117-15th St., N. W., Washington, D. C., and Bradley Hills, Bethesda, Md.

STOCKENBERG, Ruben, (1922), Sales Engr., (for mail), Johnson Service Co., 1355 W. Washington Blvd., Chicago, Ill.

STOCKLY, Harold A., (1925), 240 S. El Molins St., Alhambra, Calif.

STOCKWELL, William R., (Junior 1901; 1903), Gen. Mgr., Weil-McLain Co., Michigan City, Ind.

STOKES, Ralph E., (1920), Vtg. Engr., (for mail), Ilg Elec. Vtg. Co., 1018 Bessemer Bldg., Pittsburgh, and 150 S. Bryant Ave., Bellevue, Pa.

STONE, Eugene R., (1913), Pres., Stone-Underhill Htg. & Vtg. Co., 171 Harrison Ave., Boston, and 51 Elm Ave., Quincy, Mass.

STONE, George F., (1918), Estimator, Galligan Bros., 716 South 51st St., and (for mail), 4520 N. Carlisle St., Philadelphia, Pa.

STOREY, Gilbert C., (1927), Secy., Mgr., (for mail), Windsor Water Commissioners, City Hall, Windsor, and 372 Eastlawn Blvd., Riverside, Ont., Can.

STOREY, Thomas G., (Associate 1925), Sales Supervisor, Public Service Co. of Colorado, 900 15th St., and (for mail), 868 S. Gilpin St., Denver, Colo.

STRACHAN, John S., (1928), Pres., (for mail), Strachan-Harrison, Inc., Cons. Engrs., 243 State St., and 121 Furman St., Schenectady, N. Y.

STRANDWITZ, William J., (1919), Secy. and Treas., (for mail), Strandwitz & Scott, Inc., 537-49 S. Second St., Camden, and Hawthorne Ave., Haddonfield, N. J.

STRONG, Edward A., Jr., (Associate 1928), Co-Partner, (for mail), Strong Bros., 309 N. Alabama St., and 4354 College Ave., Indianapolis, Ind.

STRONG, Ralph C., (1919), 4515 Larchwood Ave., Philadelphia, Pa.

STROUSE, Sidney B., (1921), Dist. Mgr., (for mail), Warren Webster & Co., 429 Guarantee Trust Bldg., and 22 S. Illinois Ave., Atlantic City, N. J.

STURGES, Heyward A., (Junior 1926; Associate 1928), Detroit Mgr., International Heater Co., 1114 Dime Bk. Bldg., Detroit, Mich., and (for mail), 90 N. W. O'Connor, St. Albans, Vt.

SUITS, George A., (1923), Mgr., Hoffman Specialty Co., 26 Stanley Ave., Medford, Mass.

SULLIVAN, Daniel A., (1923), Miller & Brady, Inc., 210 East 38th St., and 3178 Rochambeau Ave., New York, N. Y.

SUTCLIFFE, Arthur G., (Associate 1918; 1922), Engr., Ilg Elec. Vtg. Co., 2850 N. Crawford Ave., and (for mail), 4146 N. St. Louis Ave., Chicago, Ill.

SUTTERLEY, W. W., (1919), 503 North 52nd St., Philadelphia, Pa.

SWAIN, Wilbur A., (Associate 1926), Repr., (for mail), Jenkins Bros., 80 White St., New York, N. Y., and 133 Evergreen Place, E. Orange, N. J.

SWAN, Thomas J., (Junior 1925), Sales Engr., Hoffman Specialty Co., and 23 Athelwold St., Dorchester, Mass.

SWANEY, Carroll R., (Junior 1921), Sales Engr., (for mail), Gilbert Howe Gleason, 25 Huntington Ave., Boston, and 24 Southgate Park, W. Newton, Mass.

SWARTWOUT, Jay D., (1917), Secy. and Treas., J. D. Swartwout Co., 349 S. Weadock Ave., Saginaw, Mich.

SWEENEY, Sylvester H., (1915), Owner, 306 East 39th St., and 1916 Loring Place, New York, N. Y.

SWIFT, Clement K., (Associate 1928), Engrg. Dept., (for mail), MacAndrews & Forbes Co., Third St. and Jefferson Ave., Camden, N. J., and 434 Oxford Rd., Upper Darby, Pa.

SZEKELY, Ernest, (1920), Consulting Engr., 500 B. & R. T. Bldg., Cleveland, O., and (for mail), 1140 Maple Ave., Evanston, Ill.

T

TAGGART, Ralph C., (1912), Division Archt., Dept. of Public Works, New York State, 14 Lyon Ave., Menands, Albany, N. Y.

TALIAFERRO, Robert R., (1919), Chief Engr., Conditioning Dept., (for mail), York Htg. & Vtg. Corp., York Bldg., 16th and Sansom St., and Beechwood Park, Philadelphia, Pa.

TALLMADGE, Webster, (1924), Pres., (for mail), Webster Tallmadge & Co., Inc., 50 Church St., New York, N. Y., and 7 Claremont Place, Montclair, N. J.

TAVERNA, Frederick F., (Junior 1924; Associate, 1927), Estimator, Raisler Heating Co., 129 Amsterdam Ave., New York, N. Y., and (for mail), 406 Savoy St., Union City, N. J.

TAYLOR, John H., (Associate 1928), Pres., (for mail), Hutchison Regulator Sales Corp., 12 Lispenard St., New York, and 9344–215th Place, Queens Village, L. I., N. Y.

TAYLOR, Milton A., (Associate 1925), Asst. to Pres., (for mail), Taylor-Forbes Co., Ltd., Guelph, Ont., Can.

TAYLOR, R. Frederick, (1915), Consulting Engr., 1305 Santa Fe Bldg., and 6705 Gaston Ave., Dallas, Tex.

TEASDALE, Lawrence Aldrich, (1926), Engr., Hollis French & Allen Hubbard, 210 South St., Boston, and 28 Ardmore St., E. Braintree, Mass.

TEMPLIN, Charles L., (1921), Mgr., Southern Dist., Office, (for mail), York Htg. & Vtg. Corp., 216 Bona Allen Bldg., and 764 Greenwood Ave., Atlanta, Ga.

TENNANT, Ernest M., (Associate 1927), Sales Engr., (for mail), C. A. Dunham Co., 450 E. Ohio St., Chicago, Ill.

TERRELL, Herbert A., (1915), Carrier Engrg. Corp., 39 Cortlandt St., New York, N. Y., and (for mail), 19 Hampton St., Cranford, N. J.

THAIN, Arthur Edgar, (Associate 1926), Htg. Specialties, 2 E. Biddle St., and (for mail), 2116 Mt. Holly St., Baltimore, Md.

THATCHER, George S., (1919), Pres., (for mail), Thatcher Heating Co., 455 E. Exchange St., and 140 Morningside Drive, Arkon, O.

THEISEN, Edwin F., (1922), Pres. and Htg. Engr., Industrial Plumbing & Htg. Co., 606 Second St., and (for mail), 1835 Des Moines St., Ft. Madison, Ia.

THEORELL, Hugo G. T., (1902), Consulting Engr., 4 Skoldungatan, Stockholm, Sweden.

THINN, Christian A., (1921), Chief Engr., C. A. Dunham Co., 450 E. Ohio St., Chicago, Ill.

THOMAS, Bernard A., (Junior 1923), Sales Engr., (for mail), Crane Co., 705 W. Main St., and 2555 West 21st St., Oklahoma City, Okla.

THOMAS, Herbert G., (1917), Sales Engr., Warren Webster & Co., 549 W. Washington St., Chicago, and (for mail), 2312 Ridge Ave., Evanston, Ill.

THOMAS, Melvern F., (1909), Consulting Engr., (for mail), 229 College St., and 24 Rivercrest Ave., Toronto, Ont., Can.

THOMAS, Norman A., (1928), Pres., (for mail), Thomas Heating Co., 723 Center St., and 824 Monroe Ave., Racine, Wis.

THOMAS, R. H., (1920), Pres., (for mail), Economy Pumping Machine Co., 3431 West 48th Place, Chicago, and 426 Forest Ave., Oak Park, Ill.

THOMPSON, Charles, (Associate 1927), 720 13th St., Sacremento, Calif.

THOMPSON, James, (1920), Pres., (for mail), Philadelphia Boiler Works, 1737 Filbert St., Philadelphia, and 158 Stoneway Lane, Bala, Pa.

THOMPSON, Nelson S.,* (Junior 1897; 1917), Chief Mech. and Elec. Engr., Office of Supervising Engr., U. S. Treasury Dept., and (for mail), 1615 Hobart St., N.W., Washington, D. C.

THOMPSON, Richard C., (1927), Sales Engr., (for mail), Power Equipment Co., 250 Stuart St., Boston, and P. O. Box 257, Cohasset, Mass.

THOMPSON, William P., Jr., (1915), (for mail), Thompson Bros., 520 Buttonwood St., and 1349 Colwyn St., Philadelphia, Pa.

THOMSEN, William T., (1919), Secy. and Treas., International Engrg. & Supply Co., Suite 609, Tower Bldg., and (for mail), 3636 Fillmore St., St. Louis, Mo.

THOMSON, Thomas N., (1927), Sanitary and Htg. Engr., 37 Irwin Place, Huntington, L. I., N. Y.

THORNTON, Roger T., (1919), Engr., (for mail), Buffalo Forge Co., 490 Broadway, and 46 Burbank Ter., Buffalo, N. Y.

THRUSH, Homer A., (1918), Pres., (for mail), H. A. Thrush & Co., 21-23 E. River St., Peru, Ind.

THUEM, Adolph E., (Junior 1922; Associate 1926), Htg. and Vtg. Engr., Board of Education, Flatbush Ave. Ext. and Concord St., Brooklyn, N. Y., and (for mail), 132–39th St., Union City, N. J.

TIBBETS, John C., (1920), Htg. and Vtg. Engr., B. & O. R. R. Co., 1303 B. & O. Central Bldg., Baltimore, and (for mail), P. O. Box 106, Ellicott City, Md.

TILDEN, Elwyn E., (1924), (for mail), Warren Webster & Co., 76 Summer St., Boston, and Holbrook, Mass.

TIMMERMAN, Manford M., (Junior 1921; 1925), Engr., Works, Engrg Dept., Westinghouse Elec. & Mfg. Co., E. Pittsburgh, and (for mail), 859 E. Hutchinson Ave., Swissvale, Pa.

TIMMIS, Pierce, (1920), Service Equipment Engr., United Engineers & Constructors, 1401 Arch St., Philadelphia, and (for mail), 1122 Montgomery Ave., Narberth, Pa.

TIMMIS, W. Walter, (Associate 1925), Htg. and Vtg. Engr., 315 Fifth Ave., New York, and (for mail), Oak Lane, Glen Cove, N. Y.

TINKER, A. K., (1927), Western N. Y. Sales Mgr., Landon Radiator Co., Inc., 281 Delaware Ave., and (for mail), 69 Shoshone St., Buffalo, N. Y.

TINKER, William E., (Associate 1922), (for mail), Natl. Radiator Co., 121 N. Broad St., and 600 South 48th St., Philadelphia, Pa.

TISNOWER, William, (1923), Mech. Engr., (for mail), Board of Education, 131 Livingston St., Brooklyn, and 3611–31st Ave., Long Island City, N. Y.

TITUS, Marvin Sinclair, (1928), Htg. and Vtg. Engr., Buick Motor Co., No. 25 Eng. Dept., and (for mail), 2617 Eastlawn Drive, Flint, Mich.

TJERSLAND, Alf, (Junior 1906; 1916), E. Sunde & Co., Christiania, Norway.

TOBIN, George J., (1905), Sanitary, Htg. and Vtg. Engr., (for mail), 187 North Ave., and 510 Grant Ave., Plainfield, N. J.

TOMLINSON, Malcolm C. W., (1924), Mech. Engr., Western Elec. Co., Kearney, and (for mail), 106a Euclid Ave., Loch Arbour, N. J.

TOOKER, Charles C., (1918), Owner, Plbg. and Htg., 116 North 27th St., and (for mail), 208 Terry Ave., Billings, Mont.

TRANE, Reuben N.* (1915), Pres., (for mail), The Trane Co., Htg. Specialty Mfgrs., and 126 South 15th St., LaCrosse, Wis.

TRUITT, Joseph E., (Associate 1911; 1920), Pres., Autovent Fan & Blower Co., 1805-27 N. Kostner Ave., Chicago, Ill.

TRUMBO, Silas M., (Associate 1926), Sales Engr., Buffalo Forge Co., 562 W. Washington Blvd., Chicago, and 921 Franklin St., Downers Grove, Ill.

TUCKER, Frank N., (1926), Field Engr., (for mail), Ilg Elec. Vtg. Co., Rm. 1108, 13 Park Row, and 174 Nagle Ave., Apt. 22, New York, N. Y.

TURNER, John W., (1928), Chief Engr., (for mail), Pacific Steel Boiler Corp., and 233 Stewart Ave., Waukegan, Ill.

TURNO, Walter G. W., (Associate 1912; 1917), Engr. and Estimator, 71 Lafayette Ave., E. Orange, N. J.

TUSCH, Walter, (1917), Htg. and Vtg. Engr., Tenny & Ohmes, 101 Park Ave., New York, and (for mail), 881 Sterling Place, Brooklyn, N. Y.

TUTTLE, J. Frank, (1913), Mgr., (for mail), Warren Webster & Co., 76 Summer St., Boston, and 5 Lewis Rd., Winchester, Mass.

TWIST, Charles F., (1921), Secy. and Treas., (for mail), Ashwell, Twist & Cook, Inc., 967 Thomas St., and 2310 Tenth Ave., N., Seattle, Wash.

TYLER, Frank T., (1922), Asst. Sales Mgr., (for mail), Herman Nelson Corp., 1824 Third Ave., and 1615 Eighth Ave., Moline, Ill.

TYLER, Roy Dexter, (1928), Dist. Sales Mgr., Modine Mfg. Co., 3116 Market St., Philadelphia, and (for mail), 300 Park Ave., Swarthmore, Pa.

TYSON, William H., (1923), Htg. and Vtg. Engr., (for mail), Goodyear Tire & Rubber Co., and 320 Afton Ave., Akron, O.

U

UHL, Edwin J., (1925), Sales Engr., Uhl Co., 132 S. Tenth St., and 3324 Lyndale Ave., S., Minneapolis, Minn.

UHL, Willard F., (1918), (for mail), Uhl Co., 132 S. Tenth St., and 4716 Lyndale Ave., S., Minneapolis, Minn.

UHLHORN, W. J., (1920), Sales Engr., Drying Systems, Inc., 1800 Foster Ave., Chicago, and (for mail), 733 S. Highland Ave., Oak Park, Ill.

ULLMAN, Herbert G., (Associate 1928), Secy. of Lab., (for mail), Inst. of Thermal Research, American Radiator Co., 675 Bronx River Rd., Yonkers, and 35 Oakland Ave., Crestwood Sta., Tuckahoe, N. Y.

ULRICH, Kay Flemming, (Junior 1926), Mech. Engr., L. Ulrich, Smedegade, Slagelse, Denmark.

UNDERHILL, William W., (1913), Treas., (for mail), Stone-Underhill Htg. & Vtg. Co., 171 Harrison Ave., Boston, and 15 Kinwood St., Brookline, Mass.

V

VALENTINE, Howard D.,* (1924), Director Sales Engrg., (for mail), Central Huckon Gas & Elec. Corp., 50 Market St., Poughkeepsie, N. Y.

VALIQUET, Harry H., (Associate 1926), Htg. Contracting, H. H. Valiquet Co., 2624 Lawrence Ave., and (for mail), 6436 N. Albany Ave., Chicago, Ill.

VAN ALEN, Walter T., (1924), Sales Engr., 1300 Darlington Rd., Beaver Falls, Pa.

VAN ALSTYNE, Richmond F., (Associate 1928), Br. Mgr., (for mail), Johnson Service Co., 312 E. Ohio St., and 323 East 49th St., Indianapolis, Ind.

VANCE, Louis G., (1919), Br. Mgr., The Trane Co., 517 Garrett Bldg., and (for mail), 3601 Garrison Ave., Baltimore, Md.

VAN NORDEN, Ernest M., (1923), Civil Engr., The New York Edison Co., 130 East 15th St., New York, and 168 Brixton Rd., Garden City, Nassau Co., N. Y.

VAN SICKLE, William B., (1915), Pres., (for mail), The W. B. Van Sickle Co., 707 Frankfort Ave., Cleveland, and 1530 Grace Ave., Lakewood, O.

VAN ZANDT, John H., (1914), Mfgrs. Agent, 408 Dallas Natl. Bk. Bldg., and 4416 Bryan St., Dallas, Tex.

VAUX, Frederick J., (1919), Vice-Pres. and Gen. Mgr., Monitor Bi-Loop Radiator Co., and (for mail), 202 E. King St., Lancaster, Pa.

VAUX, Noble, (Associate 1923), Htg. Engr., R. T. Vaux & Son, 12 Fawcett St., and (for mail), 11 Holmelands Park S., Sunderland, Eng.

VER HALEN, Edward T., (Associate 1925), Edw. T. Ver Halen, Inc., 610 Milwaukee St., Milwaukee, Wis.

VERNER, William F.,* (1913), Mech. Engr., (for mail), Verner, Wilhelm & Molby, 824 Book Bldg., Detroit, and 908 Lincoln Ave., Ann Arbor, Mich.

VERNON, J. Rexford, (Associate 1926), Sales Engr., (for mail), Johnson Service Co., 1355 Washington Blvd., Chicago, and 619 Brummel St., Evanston, Ill.

VIVARTTAS, E. Arnold, (1910), Mech. Engr., Jardine, Hill & Murdock, 347 Madison Ave., New York, and (for mail), 10 Midwood St., Brooklyn, N. Y.

VOGEL, Andrew, (1926), Plant Engr., (for mail), General Electric Co., and 611 Lenox Rd., Schenectady, N. Y.

VOGELBACH, Oscar, (1923), Htg. and Vtg. Engr., Guilbert & Betelle, Archts., Brandford Place, Chamber of Commerce Bldg., Newark, and 195 Devon St., Kearney, N. J.

VOGT, J. H., (Associate 1925), (for mail), 124 East 28th St., New York, and 87 Grant Ave., Brooklyn, N. Y.

VOIGT, Charles O., (1921), Engr., The Sterns Roger Mfg. Co., 1720 California St., and 60 Albion St., Denver, Colo.

VOLK, Joseph H., (1923), Pres., (for mail), Thos. E. Hoye Htg. Co., 1910 St. Paul Ave., and 949 Muskego Ave., Milwaukee, Wis.

VOORHEES, Guy A., (1922), Engr., Century Htg. Service Co., 633 S. Delaware St., and (for mail), 3451 Broadway, Indianapolis, Ind.

W

WADE, Norman S., (1926), Asst. Supt., Steam Htg. Service Dept., (for mail), Edison Elec. Illuminating Co. of Boston, 39 Boylston St., Boston, Mass., and 19 Walsingham St., Newton, Mass.

WAECHTER, Herman Paul, (Junior 1927), Htg. and Vtg. Squad Leader, New York Edison Co., 44 East 23rd St., New York, and (for mail), 89 Sherman Ave., Tompkinsville, N. Y.

WAGNER, A. M., (Associate 1921), Mgr., American Radiator Co., 692 Prior Ave., N., St. Paul, and 1626 West 25th St., Minneapolis, Minn.

WAGNER, John P., (Associate 1921), The Stoker Co., 859 Church Lane, Philadelphia, Pa.

WALDON, Charles W., (Associate 1924), (for mail), American Larson Vtg. Co., 204 Keystone Bk. Bldg., Pittsburgh, Pa., and 1006 Ninth St., Portsmouth, O.

WALKER, Alex., (Associate 1925), Br. Mgr., (for mail), C. A. Dunham and Powers Regulator Co., 311 Dominion Bk. Bldg., Calgary, Alta, Can.

WALKER, George F., (Junior 1925), Sales Engr., Spencer Heater Co., and (for mail), 1561 Sanderson Ave., Scranton, Pa.

WALKER, James B., (1919), (for mail), Pittsburgh Htg. Co., 715 Magee Bldg., and 202 Iroquois Apt., Oakland, Pittsburgh, Pa.

WALKER, James H.,* (1916), Supt., Central Heating, (for mail), Detroit Edison Co., 2000 Second Ave., and 1520 Virginia Park, Detroit, Mich.

WALKER, William K., (Junior 1924), Sales Engr., (for mail), York Htg. & Vtg. Corp., 149 Broadway, New York, and 191-02 Central Ave., St. Albans, L. I., N. Y.

WALLACE, George J., (1923), Htg. and Vtg. Engr., 1006 First Ave., New York and (for mail), 27-36 Ericsson St., E. Elmhurst, L. I., N. Y.

WALSH, Arthur F., (Associate 1923), Htg. and Vtg. Contractor, 7445 Exchange Ave., and 7536 S. Shore Drive, Chicago, Ill.

WALSH, John Henry, (Junior 1927), Htg. and Vtg. Engr., 10 Fairview Ave., New York, N. Y.

WALSH, Joseph F., (1928), Erecting Engr., Jarcho Bros., 215 East 37th St., New York, and (for mail), 1163 Ocean Parkway, Brooklyn, N. Y.

WALSH, Malcolm, (1924), Vice-Pres., (for mail), Walsh & Wertheim, 55 W. Houston St., New York, and 720 Forest Ave., S. I., N. Y.

WALTERS, Arthur L., (Junior 1924; Associate 1925; 1926), Chief Engr., (for mail), Langenberg Mfg. Co., 4519 N. Euclid Ave., St. Louis, and 7284 Richmond Place, Maplewood, Mo.

WALTERS, Victor, (Junior 1924), Htg. and Vtg. Engr., (for mail), 1131 N. Wells St., and 7053 St. Lawrence Ave., Chicago, Ill.

WALTERS, William T., (1917), Engr., Illinois Engrg. Co., N. E., Cor. 21st St. and Racine Ave., and (for mail), 8053 Ingleside Ave., Apt. 2, Chicago, Ill.

WALTHER, Harry J., (1919), Salesman, (for mail), The H. B. Smith Co., 49th andGrays Aves., and 1115 Duncannon Ave., Philadelphia, Pa.

WALTHER, Owen N., (1919), Pres. and Gen. Mgr., Walther Industries, Inc., Gibson, La.

WALTHER, Vernon H., (Junior 1927; 1928), Asst. Mech. Engr., C. W. & Geo. L. Rapp, Archts., 190 N. State St., and (for mail), 6821 Osceola Ave., Edison Park, Chicago, Ill.

WALTHERTHUM, John J., (Associate 1922), Htg. and Vtg. Contracting, 173 East 62nd St., New York, N. Y., and 834 Grant St., Jersey City, N. J.

WALTON, Hiram L., (1916), Mech. Engr., (for mail), Smith, Hinchman & Grylls, 800 Marquette Bldg., Detroit, and 218 Monterey Ave., Highland Park, Mich.

WANDLESS, F. W., (1925), Chief Engr., (for mail), Haynes Selling Co., 2013 Sansom St., Philadelphia, and P. O. Box 308, Berwyn, Pa.

WARD, George C., (1925), Demonstrator and Ventilation Expert, Bureau Industrial Hygiene, State Dept. of Labor, 124 East 28th St., New York, and (for mail), 86–87th St., Brooklyn, N. Y.

WARD, Lawrence Thomas, (Associate 1928), Experimental and Research Engr., (for mail), David Lupton's Sons Co., Allegeny Ave. and Tulip St., and 1457 Lardner St., Philadelphia, Pa.

WARD, Oscar G., (1919), Dist. Mgr., (for mail), Johnson Service Co., 1230 California St., and 1221 Sherman St., Denver, Colo.

WARREN, Clarence N., (1919), Vice-Pres. and Engr., Hayes Bros., Inc., 236 W. Vermont St., and (for mail), 419 East 48th St., Indianapolis, Ind.

WASH, William Percy, (1923), Sales Engr., (for mail), Richmond Radiator Co.., P. O. Box 381, and 131 Wellington Ave., Roanoke, Va.

WATERS, George G., (Associate 1926), Dist. Mgr., (for mail), American Blower Co., 604 Bldg. and Loan Bldg., and 329 Gladstone, S. E., Grand Rapids, Mich.

WATSON, John Howard, (1925), Engr., Drying Systems, Inc., 1800 Foster Ave., and (for mail), 2021 Berwyn Ave., Chicago, Ill.

WATSON, M. Barry, (1928), Consulting Engr., Associate, Harry H. Angus, Bloor and Balmuto Sts., and 121 Welland Ave., Toronto, 5, Ont., Can.

WATTERS, Peter J., (1921), Mgr., John Watters, 55 Church St., and (for mail), 52 Ann St., Port Richmond, S. I., N. Y.

WEAGER, T. A., (1920), Cleveland Mgr., (for mail), Buffalo Forge Co., Rockefeller Bldg., Cleveland, and 3124 Berkshire Rd., Cleveland Heights, O.

WEBB, John S., (1920), Herman Nelson Corp., Rm. 517 State Bldg., Boston, Mass.

WEBB, John William, (1926), Director, The Webb Dust Removing & Drying Co., Ltd., Tiviot Dale Chambers, and (for mail), 6 Meadows Rd., Heaton Chapel, Stockport, Eng.

WEBER, Erwin L., (1921), Consulting Engr., 723 Seaboard Bldg., S., Seattle, Wash.

WEBER, G. A., (1922), 207 Taylor St., Pittsburgh, Pa.

WEBSTER, E. Kessler, (1915), Secy. and Asst. Gen. Mgr., (for mail), Warren Webster & Co., 17th and Federal Sts., Camden, and 320 Washington Ave., Haddonfield, N. J.

WEBSTER, Warren, (Associate 1899; 1906), Pres., Warren Webster & Co., 17th and Federal Sts., Camden, and Swiss Cottage, Ocean Gate, N. J.

WEBSTER, Warren, Jr., (Junior 1927), Asst. Secy., (for mail), Warren Webster & Co., 17th and Federal Sts., Camden, and 249 W. Summit Ave., Haddonfield, N. J.

WEGMANN, Albert, (1918), Sheet Metal Contracting, A. and W. Wegmann, 2813 Fletcher St., and (for mail), 2842 N. Bonsall St., Philadelphia, Pa.

WEIDER, Frederick J., (1919), Vice-Pres., (for mail), Barr & Creelman Co., 74 Exchange St., and 40 Kenwood Ave., Rochester, N. Y.

WEIL, Martin, (Associate 1925), Secy., (for mail), Weil-McLain Co., 641 W. Lake St., and 4259 Hazel Ave., Chicago, Ill.

WEIL, Maurice I., (Associate 1928), Pres., (for mail), Chicago Pump Co., 2336 Wolfram St., and 1409 Elmdale Ave., Chicago, Ill.

WEIMER, Fred G., (Associate 1919), Milwaukee Mgr., Kewanee Boiler Co., 440 Barclay St., and (for mail), 1308 Stowell Ave., Milwaukee, Wis.

WEINSHANK, H. T., (Junior 1924), Sales Engr., (for mail), Abbot Vent. Co., Inc., 5436 S. LaSalle St., and 2638 N. Spaulding St., Chicago, Ill.

WEINSHANK, Theodore.* (1906), Board of Governors 1913), 2323 Kedzie Blvd., Chicago, Ill.

WEISS, Arthur Paul, (1928), Asst. Treas., Burnham Boiler Corp., 2 Main St., Irvington, and (for mail), Farrington Ave., Philipse Manor, N. Tarrytown, N. Y.

WEISS, Carl A., (Associate 1924), Supt., (for mail), Kornbrodt Kornice Ko., 1811-13-15 Troost Ave., and 105 East 68th St., Kansas City, Mo.

WEIXEL, Albert L., (1928), Consulting Engr., (for mail), 228 N. LaSalle St., and 6647 Newgard Ave., Chicago, Ill.

WELAMB, Victor N., (1918), Contractor, (for mail), V. N. Welamb Co., 2313 Walnut St., and 1741 North 33rd St., Philadelphia, Pa.

WELLS, Harry N., (Junior 1927; Associate 1928), Htg. and Vtg. Engr., Guilbert & Betelle, 811 Chamber of Commerce Bldg., Newark, and (for mail), 44 Fuller Place, Irvington, N. J.

WELSH, Harry S.,* (1906), Pres., The Boiler & Radiator Corp., 999 E. Main St., Rochester, N. Y.

WENDT, Edgar F., (1918), Vice-Pres. and Treas., (for mail), Buffalo Forge Co., 490 Broadway, and 731 Lafayette Ave., Buffalo, N. Y.

WENDT, Henry W., (1917), Pres., (for mail), Buffalo Forge Co., 490 Broadway, and 120 Lincoln Parkway, Buffalo, N. Y.

WEST, Baird F., (Junior 1928), Adv. Dept., (for mail), American Radiator Co., 461 Eighth Ave., Rm. 214, and 306 West 92nd St., New York, N. Y.

WEST, Perry,* (1911), (Council 1920-1925; Treas. 1924-1925), Consulting Engr., (for mail), 13 Central Ave., and 322 Park Ave., Newark, N. J.

WHEELER, Charles W., (1916), Br. Mgr., (for mail), C. A. Dunham Co., 1104 May Bldg., Pittsburgh, and Allison Park, Pa.

WHEELER, Otto J., (1923), Mgr. and Secy., The Samuel A. Esswein Htg. & Plumbing Co., 548 W. Broad St., and 504 Linwood Ave., Columbus, O.

WHELAN, William F., (1928), Wm. F. Whelan & Bro., 222 W. Lancaster Ave., Ardmore, Pa.

WHELAN, William J., (1923), Harrigan Reid. 1705 First St., Detroit, Mich.

WHELLER, Harry S., (1916), Vice-Pres., L. J. Wing Mfg. Co., 154 West 14th St., New York, N. Y., and (for mail), 725 Union Ave., Elizabeth, N. J.

WHITAKER, Ernest C., (1925), Supt. of Engrg., Buerkel & Co., Inc., 24 Union Park St., Boston, and (for mail), 35 Sherborn St., Arlington, Mass.

WHITBY, Stephen S., (Associate 1922), Treas., (for mail), Culbert-Whitby Co., Inc., 2019 Rittenhouse St., and 127 E. Upsal St., Germantown, Philadelphia, Pa.

WHITE, E. A., (1921), Engrg., Dept., (for mail), Crane Co., 30 South 16th St., and 5244 Nottingham, St. Louis, Mo.

WHITE, Elwood S., (1921), Pres., (for mail), Taco Heaters, Inc., 342 Madison Ave., New York, N. Y., and Sound Beach, Conn.

WHITE, M. G., Jr., (1925), Rm. 1010, 41 East 42nd St., New York, N. Y.

WHITELAW, H. Leigh, (1916), Vice-Pres. and Gen. Mgr., (for mail), American Gas Products Corp., 376 Lafayette St., New York, and 18 Locust Ave., Larchmont, N. Y.

WHITLEY, James, (1919), Consulting Engr., Whiteley & Sanders, 3000 Grand River Ave., and 520 Navahoe Ave., Detroit, Mich.

WHITMER, R. P., (Associate 1927), Secy., (for mail), American Foundry & Furnace Co., 915 E. Washington St., and 1402 E. Washington St., Bloomington, Ill.

WHITNAH, C. S., (1927), 1106 Lakeside Ct., Duluth, Minn.

WHITTEMORE, Edward H., (1920), Engr., (for mail), Stone & Webster, 49 Federal St., Boston, and 96 Church St., W. Roxbury, Mass.

WHITTEN, H. E., (1924), Pres., (for mail), H. E. Whitten Co., 9 Federal Circuit, Boston, and 56 Highland Rd., W. Somerville, Mass.

WHITTEN, Herbert W.,* (Associate 1908; 1909), Htg. and Mech. Engr., Chamberlin Metal Weather Strip Co., (for mail), 134 Congress St., and 254 W. Newton St., Boston, Mass.

WHITTINGTON, W. Penrose, (1928), Pres., W. P. Whittington, Inc., 404 Lumber Insurance Bldg., Indianapolis, Ind.

WHOMES, Harry, (1926), 3269 N. Penna. St., Indianapolis, Ind.

WHY, H. Berkeley, (1919), Engr., (for mail), Galligan Bros., 716 South 51st St., and 640 W. Sedgwick St., Germantown, Philadelphia, Pa.

WIDDICOMBE, R. A., (1903), 1120 Lake Shore Drive, Chicago, Ill.

WIEGNER, Henry B., (1919), Mgr., Johnson Service Co., 31 Waltham St., Boston, and 143 Standish Rd., Watertown, Mass.

WIERSIG, R. H., (Associate 1927), Pres., (for mail), Rud Wiersig, 2311 N. California Ave., and 3001 N. Kilpatrick Ave., Chicago, Ill.

WIGGS, G. Lorne, (Junior 1924), Mech. Engr., (for mail), 80-90 St. Paul St., and 85 Brown Ave., Quebec, P. Q., Can.

WIGLE, Bruce M., (Associate 1926), Owner, Bruce Wigle Plumbing & Htg. Co., 9117 Hamilton Ave., and 1814 Holmur Ave., Detroit, Mich.

WILD, Walter H., Mgr., (for mail), Heggie Simplex Boiler Co., Land Title Bldg., Philadelphia, and 122 Cynwyd Rd., Bala Cynwyd, Pa.

WILDE, Ray S. M., (1916), Consulting Engr., (for mail), 1216 Michigan Theatre Bldg., Detroit, and 194 Connecticut Ave., Highland Park, Mich.

WILDER, Edward L., (1915), Mgr. Industrial Sales Dept., (for mail), Rochester Gas & Electric Corp., 89 East Ave., and 16 Ericsson St., Rochester, N. Y.

WILEY, Charles S., (1921), Htg. and Vtg. Engr., (for mail), Eastman Kodak Co., Kodak Park, and 239 Mulberry St., Rochester, N. Y.

WILEY, Edgar C., (1909), Consulting Engr., Wiley & Wilson, Lynchburg, Va.

WILLARD, Arthur C., (1914), (Presidental Member), (2nd Vice-Pres. 1926; 1st Vice-Pres. 1927; Council 1925-1926), Prof. Htg. and Vtg., and Head of Dept. of Mech. Engrg., (for mail), University of Illinois, and 1208 W. California St., Urbana, Ill.

WILLIAMS, Allen W., (Associate 1915), Managing Dir., (for mail), National Warm Air Heating & Ventilating Assn., 174 E. Long St., Columbus, and 51 Meadow Park, Bexley, O.

WILLIAMS, Grover M., (1928), Secy.-Treas., (for mail), Bevington-Williams, Inc., 1134 Indiana Pythian Bldg., and 316 Berkeley Rd., Indianapolis, Ind.

WILLIAMS, J. M., (Associate 1925), Pres., (for mail), Williams Radiator Co., 1865 W. Cordova St., and 861 Harcourt Ave., Los Angeles, Calif.

WILLIAMS, J. McFarland, Jr., (Junior 1927; Associate 1928), Sales Engr., 2401 Garrison Ave., Baltimore, Md.

WILLIAMS, J. Walter, (1915), Pres. and Treas., Forest City Plumbing Co., 332 E. State St., and 922 E. State St., Ithaca, N. Y.

WILLIAMS, O. L., (Associate 1925), 207 N. Hiland Ave., E. Liberty Station, Pittsburgh, Pa.

WILLIAMS, Robert Eubank, (1926), Consulting Engr., (for mail), 308 Home Insurance Bldg., and 2427 Broadway, Little Rock, Ark.

WILLIAMSON, A. H., (Associate 1915), Sales Mgr., (for mail), American Radiator Co. of Michigan, 1344 Broadway, and 2272 Glynn Court, Detroit, Mich.

WILLIAMSON, Fred W., (1914), Consulting Engr., 1418 East 34th St., Brooklyn, N. Y.

WILLIS, Frederick H., (1921), Consulting Engr., (for mail), 922 Gas and Elec. Bldg., and 1110 Jackson St., Denver, Colo.

WILLIS, Roy C., (1927), Vice-Pres. and Secy. (for mail), Vapor Engrg. Co., 489 Fifth Ave., and 227 Audubon Ave., New York, N. Y.

WILLIS, William Jasper, (1927), c/o Mrs. J. A. Ruble, 351 Kirk Place, San Antonio, Tex.

WILMOT, Chas. S., (1919), Htg., Plbg. and Vtg. Engr., Day & Zimmermann Engrg. & Const. Co., 112 N. Broad St., Philadelphia, Pa.

WILSON, Benjamin W., (1922), Htg. and Vtg. Engr., (for mail), The Ballinger Co., S.E. Cor. 12th and Chestnut Sts., and 5935 Windsor Ave., W. Philadelphia, Pa.

WILSON, Charles H., (1920), Htg. and Vtg. Engr., Fuller & Warren Co., 1403 Park Blvd., Troy, N. Y.

WILSON, Ernest J. F., (1923), Partner, Wiley & Wilson, Consulting Engrs., 801 Main St., Lynchburg, Va.

WILSON, Eugene K., (1919), Wilson & Co., (for mail), 1017 Duke St., and 12 Lafayette Blvd., Norfolk, Va.

WILSON, F. A., (1910), New York Edison Co., 32 West 48th St., New York, and 20945–110th Ave., Bellaire, L. I., N. Y.

WILSON, George T., (1925), Gurney Foundry Co., Ltd., 500 King St., Toronto, and (for mail), Tyre Ave., Islington, Ont., Can.

WILSON, Harry A., (1903), P. O. Box 155, Washington, R. I.

WILSON, Howard M., (Associate 1925), Br. Mgr., (for mail), Standard Heater Co., 136 Federal St., Boston, and 15 Chestnut St., Wellesley Hill, Mass.

WILSON, J. J., (Charter Member). Consulting Engr., 5514 Paschall Ave., Philadelphia, Pa.

WILSON, William H., (Associate 1923), Br. Mgr., (for mail), Johnson Service Co., 149-159 Michigan St., and 431 Olive St., Milwaukee, Wis.

WILSON, William S., (Associate 1924), Mgr. Lands Dept., The Lake Superior Corp., and 210 McGregor Ave., Sault Ste. Marie, Ontario, Can.

WINCH, Franklin R., (1925), Consulting Engr., (for mail), 1031 Broadway, Los Angeles, and 1058 Bedford, Beverly Hills, Calif.

WINTERBOTTOM, John W., (1915), Pres., Winterbottom Supply Co., Commercial and Miles St., and 432 Denver St., Waterloo, Ia.

WINTERBOTTOM, Ralph F., (Associate 1923), Mgr., Faultless Heater Mfg. Co., and (for mail), P. O. Box 2217, Sta. A, Waterloo, Ia.

WINTERER. Frank C., (1920), Htg. Dept., (for mail), Cochran-Sargent Co., Third and Broadway, and 836 Juno St., St. Paul, Minn.

WISE, Frank W., (Associate 1918), Sales Engr., (for mail), General Boilers Co., 207 Davidson Bldg., 615 City Bk. Bldg., and 2751 Charlotte Ave., Kansas City, Mo.

WISE, Mason W., (1923), Prop., (for mail), M. W. Wise Co., 215 Glenn Bldg., and R. F. D. No. 2, Atlanta, Ga.

WITTLEDER, Edward A., (Junior 1926), Mech. Draftsman, W. W. Alschlager, Archt., and (for mail), 3429 Medill Ave., Chicago, Ill.

WOLF, J. C., (1923), Mech. Engr., B. F. Sturtevant Co., and 1367 Stowell Ave., Milwaukee, Wis.

WOLFF, Oscar H., (1926), Repr., Hoffman Specialty Co., 6232 Oakland Ave., St. Louis, Mo.

WOLFF, Richard A., (Junior 1915;1919), Pres., (for mail), Wolff & Munier, Inc., 222 East 41st St., New York, and Hewlett, L. I., N. Y.

WOLFSFELD, Charles F., (1923), Chief Draftsman, Board of Education, Flatbush Ave. and Concord St., Brooklyn, and (for mail), Vista Ave., Bayside, L. I., N. Y.

WOOD, James Sydney, (1926), Estimator, (for mail), The Bennett & Wright Co., Ltd., 72 Queen St., E., Toronto, Ont., Can.

WOODLING, Miner D., (1926), Prop., (for mail), Miner D. Woodling Htg. & Vtg. Co., 810 Midland Bldg., and 301 West 51st Terrace, Kansas City, Mo.

WOOLLEY, Thos. R., (1916), Sales Engr., Woolley Engineering Co., 2457 Woodward Ave., and (for mail), 3267 Tyler Ave., Detroit, Mich.

WOOLSTON, Alfred H., (1919), Member of Firm, (for mail), Bowers Bros. & Co., 2015 Sansom St., and 4815 North 12th St., Philadelphia, Pa.

WOOLSTON, C. E., (1924), Vice-Pres. and Treas., (for mail), Smith Twin Tubular Boiler Co., 38-42 E. Allen St., and 1510 North 28th St., Philadelphia, Pa.

WORM, Amdi, (Associate 1924), Flaxlinum Insulating Co., 1425 Grand Ave., and (for mail), 2424 East 68th St., Kansas City, Mo.

WORSHAM, Herman, (1925), Dist. Mgr., Carrier Engrg. Corp., 850 Frelinghuysen Ave., Newark, N. J.

WORTH, William Ellison, (Associate 1927), Industrial Engr., (for mail), 15 Moore St., New York, and Apt. 6-A, Pelham Gables, Pelham, N. Y.

WORTHING, E., (1923), Bayley Mfg. Co., 732 Greenbush St., and 56 Prospect St., Milwaukee, Wis.

WRIGHT, Charles Leslie, (1925), Mgr., Htg. and Vtg. Dept., (for mail), Geo. E. Gibson Co., Inc., 441 Lexington Ave., and 54 West 94th St., New York, N. Y.

WRIGHT, Harris H., (1917), Mgr., C. A. Dunham Co., Pacific Steel Boiler Co., 615 City Bk. Bldg., and 1214 E. Gillham Rd., Kansas City, Mo.

WRIGHT, John C., (1926), Associate, Fletcher H. Burke—John C. Wright—Associate, 392 Franklin St., Buffalo, N. Y.

WRIGHT, Kenneth A., (1921), Mgr., (for mail), Johnson Service Co., 1113 Race St., Cincinnati, O., and 113 Orchard Rd., Ft. Mitchell, Ky.

WUNDERLICH, Milton S.,* (1925), Mech. Engr., Flaxlinum Insulating Co., Hampden and Wabash, (for mail), 1598 Laurel Ave., St. Paul, Minn.

WYLIE, Howard McW., (1917; 1925), Vice-Pres., In charge of Sales, (for mail), The Nash Engrg. Co., and 51 Elmwood Ave., South Norwalk, Conn.

Y

YAGER, John J., (1921), Pres. and Gen. Mgr., Goergen-Mackwirth Co., Inc., 817 Sycamore St., and (for mail), 272 Carlton St., Buffalo, N. Y.

YAGLOU, Constantin P.,* (1923), Instructor in Vtg., (for mail), Harvard School of Public Health, 55 Van Dyke St., Boston 17, Mass., and 1626 Commonwealth Ave., Boston, Mass.

YAMASAKI, Kanjiro, (Associate 1923), Htg. Engr., Daiwa Kogyo Co., Ltd., First Mutual Bldg., Rm. 216, No. 53 chome Denmacho, Kyobashi-Ku, Tokio, Japan.

YARDLEY, Ralph W., (1920), Asst. Archt., Board of Education, City of Chicago, and (for mail), The Newberry, 817 N. Dearborn St., Chicago, Ill.

YATES, Walter, (1902), Governing Dir., (for mail), Matthews & Yates, Ltd., Cyclone Works and Parksend, Swinton, Manchester, Eng.

Z

ZACK, Hans J., (1928), Prop. (for mail), The Zack Co., 2311 Van Buren St., and 2057 N. Spaulding Ave., Chicago, Ill.

ZECK, Alex., (1904), Pres., Alex Zeck & Son Co., Morgantown, W. Va.

ZELDITCH, Morris, (1928), Htg. Engr., Rush Mchy. Co., 32 E. Carson St., and (for mail), 2301 Lutz Ave., Pittsburgh, Pa.

ZIEL, Herbert E., (1924), Albert Kahn, 1000 Marquette Bldg., Detroit, Mich.

ZINGSHEIM, George Godfrey, (1927), Br. Mgr., Richardson & Boynton Co., 301 N. Seventh St., and (for mail), 4011 Pleasant Ave., Minneapolis, Minn.

ZOKELT, C. G., (1921), Mgr., (for mail), 414 Central Bldg., and 2366-16th Ave., S., Seattle, Wash.

ZORB, Henry Phillip, (1927), Master Fitter, 2620 Fourth Ave., Detroit, Mich.

ZUEHLKE, Rudolph, (1923), (for mail), Zuehlke Heat. Co., 281 N. Main St., Wauwatosa, Wis.

ZUHLKE, W. R., (1928), Engr., American Radiator Co., 675 Bronx River Rd., and (for mail), 530 McLean Ave., Yonkers, N. Y.

Summary of Membership

(Corrected to December 1, 1928)

UNITED STATES

Alabama	4	Missouri	106
Arkansas	2	Montana	4
California	24	Nebraska	2
Colorado	17	New Jersey	91
Connecticut	22	New York	410
Delaware	4	North Carolina	6
District of Columbia	9	Ohio	76
Florida	4	Oklahoma	7
Georgia	12	Oregon	1
Illinois	273	Pennsylvania	285
Indiana	47	Rhode Island	10
Iowa	14	Tennessee	7
Kansas	10	Texas	12
Kentucky	10	Utah	1
Maine	6	Vermont	4
Maryland	17	Virginia	18
Massachusetts	107	Washington	21
Michigan	118	West Virginia	8
Minnesota	50	Wisconsin	53
Mississippi	2		
			1874

FOREIGN COUNTRIES

Belgium	1	Mexico	1
Canada	66	New Zealand	1
China	8	Norway	1
Denmark	2	Russia	1
England	17	South America	1
France	4	Sweden	1
Germany	2	Switzerland	1
Ireland	1		114
Japan	6		
		Total Membership	1988

SUMMARY OF MEMBERSHIP BY GRADES

Honorary Members	1
Presidential Members	20
Members	1421
Associate Members	428
Junior Members	118
	1988

LIST OF MEMBERS
Arranged Geographically

UNITED STATES

ALABAMA

Birmingham—
Boisclair, H. C.
Bunnell, E. W.
Festorazzi, A. O.
Lichty, C. P.

ARKANSAS

Little Rock—
Williams, R. E.

Siloam Springs—
Jones, C. R.

CALIFORNIA

Alhambra—
Stockly, H. A.

Berkeley—
Duncan, G. W., Jr.

Beverly Hills—
Nelson, H. A.

Burlingame—
Douglass, T. C.

Glendale—
Dougherty, P. J.

Huntington Park—
Berg, A. H.

Los Angeles—
Larimer, G. B.
Miller, R. A.
Ott, O. W.
Polderman, L. H.
Williams, J. M.
Winch, F. R.

Oakland—
Cummings, G. J.

Pasadena—
Bowles, P.
Gifford, R. L.
Hoffman, G. D.

Sacramento—
Thompson, C.

San Diego—
Hemingway, W. S.
Sadler, C. B.

San Francisco—
Haley, H. S.
Krueger, J. I.
Leland, W. E.
Penhallegon, R. O.

San Mateo—
Mead, W. R.

COLORADO

Colorado Springs—
Higgins, D. T.
Jardine, D. C.

Denver—
Adams, C. W.
Bagnall, G. A.
Bradbury, G. L.
Brickey, J. P.
Cullyford, F. S.
Daly, J. H.
Deranleau, R. L.
Fielding, H. H.
Foley, W. J.
Herman, H. H.
Larimer, W. M.
Storey, T. G.
Voigt, C. O.
Ward, O. G.
Willis, F. H.

CONNECTICUT

Bridgeport—
Callahan, M. J.
Clement, E. R.

Cos Cob—
Jones, A. L.

Hartford—
Byrnes, T. F.
Purcell, A. J.

New Britain—
Cadwell, W. H.

New Haven—
Fenner, E. M.
Jenkins, H. E.
Lockwood, E. H.
Menzies, F. R.

New London—
Forsberg, W.
Hopson, W. T.

Noroton Heights—
Ashley, E. E.

S. Norwalk—
Harvey, A. D.
Jennings, I. C.
Mead, E. A.
Wylie, H. M. W.

Springdale—
Broderick, J. F.

Waterbury—
Simpson, W. K.

Whitneyville—
Hoyt, W. B.

Winsted—
Griffin, P. C.
Hutton, W.

DELAWARE

Wilmington—
Gawthrop, F. H.
Kershaw, M. G.
Lownsbery, B. F.
Schoenijahn, R. P.

DISTRICT OF COLUMBIA

Washington—
Breitenbach, G. C.
Chapman, D. W.
Coward, H.
Febrey, E. J.
Gardner, S. F.
Goldstein, A. M.
Mewshaw, J. P.
Stock, E. L.
Thompson, N. S.

FLORIDA

Jacksonville—
Denson, W.
Gassler, J. H.
Johnson, R. H.

Tampa—
Smith, V. A.

GEORGIA

Atlanta—
Alger, R. W.
Clare, F. A.
Guest, P. L.
Kent, L. F.
Klein, E. W.
Lichty, A. J.
Pottinger, C. T.
Templin, C. L.
Wise, M. W.

Columbus—
Dexter, MacD.
Hartpence, C. C.

Gainesville—
Jackson, J. W.

ILLINOIS

Arlington Heights—
Atkinson, R. E.

Berwyn—
Davidson, H. MacD.
Kitch, S. B.

Bloomington—
Howell, L.
McGirl, W. J.
Nesmith, O. E.
Soper, H. A.
Whitmer, R. P.

Champaign—
Brownell, C. D.

Chicago—
Abrahamson, P.
Aeberly, J. J.
Allan, C. D.
Allen, H. D.
Andel, F. J.
Arenberg, M. K.
Armspach, O. W.
Ashenhurst, H. S.
Bailey, J. H.
Baker, E. V.
Barrows, C. E.
Beery, C. E.
Bennett, P. D.
Bennett, G. G.
Bidwell, R. E.
Birkholz, H. E.
Black, F. C.
Bloom, S. C.
Boswin, G. A.
Bracken, J. H.
Braun, L. T.
Brayton, W. M.
Broom, B. A.
Burke, G. B.
Burns, W. A.
Burt, H. J.
Calvert, N. W.
Carnahan, G. C.
Casey, B. L.
Casserly, T. D.
Chenoweth, W. H.
Cheyney, C. C.
Clark, H. J.
Clow, M. T.
Cones, B.
Cornell, H.
Coughlin, R. J.
Crannell, C. A.
Crawford, W. B.
Crone, C. E.
Currier, C. H.
Cutler, J. A.
Cutter, E. H.
Davis, J. H.
Deland, C. W.
Dewar, J. G.
Dickinson, C. E.
Dresen, W. D.
Dunham, C. A.
Ebin, L.

Emmert, L. D.
Ensign, R. M.
Faber, G. S.
Fenner, N. P.
Finan, E. J.
Finan, J. J., Sr.
Fix, F. W.
Fleming, J. P.
Frank, J. M.
Funck, E. H.
Gardner, W., Jr.
Gaylord, F. H.
Gemeny, W. J.
Getschow, G. M.
Getschow, R. M.
Gibbs, F. C.
Gilmore, R. E.
Good, M. S.
Gordon, E. G.
Gossett, E. J.
Graham, W. D.
Graves, C. C.
Graves, W. B.
Grebe, H. W.
Haas, S. L.
Haines, J. J.
Hale, J. F.
Halliday, L.
Hart, H. M.
Harter, B. B.
Hartman, F. E.
Hattis, R. E.
Hayes, J. J.
Hayward, R. B.
Heck, G. L., Jr.
Heckel, E. P.
Hennings, W. A.
Henrich, G. A.
Herbaczek, E.
Herlihy, G. F.
Herlihy, J. J.
Hill, E. V.
Hoier, W. V.
Hoover, H. E.
Hornung, J. C.
Horton, H. F.
Howatt, J.
Howe, W. W.
Hubbard, G. W.
Impey, P. F.
Jackson, C. J.
Jenson, J. S.
Johnson, C. W.
Johnson, D. H.
Jones, E. F.
Keeney, F. P.
Kehm, A.
Kehm, H. S.
Keyes, R. E.
Kirk, G. H.
Kreissl, H. G.
Lagodzinski, H. J.
Lang, L. P.
Larson, J. M.
Larson, W. C.
Lathrop, Dr. E. C.
Lautenschlager, F.
Lees, H. K.
Lenone, J. M.
Lewis, S. R.
Lippman, O. S.
Luce, G. D., Jr.
McCarthy, B. J.
McCauley, J. H., Jr.
McClellan, J. E.
McDonnell, E. N.
McEvoy, W. J.
McFarland, W. P.
McGregor, G. H.
McLelland, H. B.
Maier, H. F.
Malone, D. G.
Marschall, P. J.
Martin, A. B.
Martin, O. W.
Matchett, J. C.
Mathis, E.
Mathis, H.
Mathis, J. W.
Mathy, J., Jr.
Mauer, W. J.
May, A. O.
Mehring, G.
Mertz, W. A.
Miller, F. A.
Miller, J. E.
Miller, L. B.
Miller, R. T.
Milliken, J. H.
Moler, W. H.
Monaghan, T. H.
Monroe, H. E.
Montgomery, W. R.
Moore, R. E.
Moran, F. E.
Muth, H.
Nacey, H. M.
Narowetz, L. L., Jr.
Neiler, S. G.
Nelson, R. O.
Newport, C. F.
Nilson, A.
Nilson, K. A.
Norman, M. A.
Nulsen, C. A.
O'Brien, J. H.
O'Connell, P. M.
Offen, Ben
Olsen, C. F.
Olson, A. E.
Orr, F. B.
Pence, M. D.
Pitcher, L. J.
Pope, S. A.
Pope, W. A.
Powers, F. W.
Prentice, P. J.
Presdee, C. W.
Reid, H. P.
Rietz, E. W.
Rosenbach, R. G.
Ross, J. F.
Rottmayer, S. I.
Russell, E. A.
Russell, W. A.
Saunders, J. C.
Scheidecker, D. B.
Schwab, Q. D.
Schweim, H. J.
Seelig, L.
Seltzer, A. P.
Sheriffs, W. A.
Shufelt, H. M.
Shultz, E.
Small, J. D.
Snider, L. I.
Soper, I. N.
Spielman, G. P.
Sprague, F. H.
Stannard, J. M.
Stedman, C. N.
Stiles, H. L.
Stockenberg, R.
Sutcliffe, A. G.
Tennant, E. M.
Thinn, C. A.
Thomas, R. H.
Truitt, J. E.
Trumbo, S. M.
Valiquet, H. H.
Vernon, J. R.
Walsh, A. F.
Walters, V.
Walters, W. T.
Walther, V. H.
Watson, J. H.
Weil, M. I.
Weinshank, H. T.
Weinshank, T.
Weixel, A. L.
Widdicombe, R. A.
Wiersig, R. H.
Wittleder, E. A.
Yardley, R. W.
Zack, H. J.

Decatur—
Shorb, W. A.

Evanston—
Bergner, W. G.
Kilby, R. E.
Szekely, E.
Thomas, H. G.

Joliet—
Menk, R. W.
Russell, W. B.

Kewanee—
Baker, E. E.
Bronson, C. E.
Dickson, R. B.
Hartman, J. M.
Pursell, H. E.

LaGrange—
Eaton, B. K.
Linn, H. R.

Moline—
Munson, M. G.
Nelson, H. W.
Nordine, L. F.
Otis, G. E.
Tyler, F. T.

Oak Park—
Alexander, A. D.
Barnes, R. B.
Beling, E. H.
Blanding, G. H.
Close, P. D.
Johns, H. B.
May, E. A.
Muir, G. A.
Uhlhorn, W. J.

Park Ridge—
Gross, R. A.

Peoria—
Meyer, F. L.
Robb, J. M.

Rockford—
Merwin, G. E.

Rock Island—
Nelson, R. H.

Springfield—
Hutzel, H. F.

Urbana—
Kratz, A. P.
Willard, A. C.

Waukegan—
Collette, J. R.
Turner, J. W.

Winnetka—
Ellis, E. E.

INDIANA

Elkhart—
Shreiner, D. C.

Evansville—
Legeman, R. E.
Noland, R. W.

Hammond—
Schram, W. W.

Indianapolis—
Ammerman, C. R.
Ascher, N. C.
Bevington, W. C.
Callon, H., Jr.
Cotton, R. M.
DeHaven, I. C.
Dresen, W. D.
Edwards, R. H.
Fenstermaker, S. E.
Freyn, H. L.
Hagedon, C. H.
Hayes, J. G.
Heidenreich, G.
Jackson, G. O.
Jackson, J. O.
McMahon, T. W.
Neal, H. W.
Perham, S. H.
Peohner, R. E.
Repp, H. L.
Rotz, J. M.
Shipp, C. C.
Stitt, H. B.
Strong, E. A., Jr.
Van Alstyne, R. F.
Voorhees, G. A.
Warren, C. N.
Whittington, W. P.
Whomes, H.
Williams, G. M.

Jeffersonville—
Hancock, J. R.

Lafayette—
Hoffman, J. D.
Hotchkiss, C. H. S.
Orth, J. W.

La Porte—
Shrock, J. H.

Michigan City—
Stockwell, W. R.

Muncie—
Hutzel, M. H.
Hutzel, V. C.

Peru—
Pyle, J. W.
Thrush, H. A.

South Bend—
Leusch, V. W.

Terre Haute—
Prox, R. F.

IOWA

Ackley—
Nelson, G. O.

Cedar Rapids—
Moore, R. F.
Motejl, J. A.

Des Moines—
Bogardus, G. W.
Meston, A. B.
Somers, W. S.

Fort Madison—
Theisen, E. F.

Le Mars—
Mathey, N. J.

Sioux City—
Hagan, W. V.
Orr, M. J.

Waterloo—
Bartley, J. S., Jr.
Irwin, C. W.
Winterbottom, J. W.
Winterbottom, R. F.

KANSAS

Emporia—
Burnap, C. W.

Hutchinson—
Hertz, H. P.
Paulsen, C. E.
Stevens, H. L.

Independence—
Sellars, F. J.

Lindsborg—
Holmberg, J. A.

Topeka—
Barnes, A. R.

Wichita—
Cloud, O. E.
Johnson, R. B.
O'Connor, J. M.

KENTUCKY

Lexington—
Anderson, F. P.
Evans, J. H.
O'Bannon, L. S.

Louisville—
Helburn, I. B.
Lewis, J. C.
Murphy, H. C.
Nutting, A.
Reed, W. M.
Shrum, A. T.

LOUISIANA

Gibson—
Walther, O.

MAINE

Belfast—
Goodhue, A. P.

Portland—
Fels, A. B.
Merrill, C. J.

Presque Isle—
Noyes, G. T.

Woodfords—
Eaton, P.
Haskell, B. E.

MARYLAND

Baltimore—
Adams, H.
Collier, W. I.
Dorsey, F. C.
Eisert, H.
Erickson, H. A.
Griffin, J. J.
Leilich, R. L.
McCrea, L. W.
Meyers, J.
Posey, J.
Reeder, C. L.
Thain, A. E.
Vance, L. G.
Williams, J. M., Jr.

Ellicott City, Howard Co.—
Tibbetts, J. C.

Rockville—
Brunett, A. L.

Towson—
Seiter, J. E.

MASSACHUSSETTS

Arlington—
Shaw, N. J.
Whitaker, E. C.

Boston—
Abboud, A.
Bartlett, A. C.
Barton, R. E.
Boyden, D. S.
Boynton, D. W.
Brinton, J. W.
Brooks, T. C.
Brown, R. H.
Bryant, Dr. A. G.
Cooper, F. I.
Cummings, C. K.
Drinker, P.
Dusossoit, E. A.
Eaton, R.
Ehrenzeller, A.
Foulds, P. A. L.
Franklin, R. S.
Gifford, R. F.
Gilmore, F. P.
Gleason, G. H.
Goodrich, C. F.
Hilliard, C. E.
Hubbard, A.
Ingalls, F. D. B.
Kelley, J. J.
Kellogg, A.
Kimball, C. W.
Kirmes, E. W.
McCoy, T. F.
McKenna, Wm. N.
McLean, I. D.
Mayette, C. E.
Moulton, D.
Mower, W. P.
Myrick, J. W. H.
Osborne, M. M.
Price, W. H., Jr.
Shaw, E.
Shaw, R. E.
Smallman, W. T.
Stetson, L. R.
Stone, E. R.
Swaney, C. R.
Teasdale, L. A.
Thompson, R. C.
Tilden, E. E.
Tuttle, J. F.
Underhill, W. W.
Wade, N. S.
Webb, J. S.
Whittemore, E. H.
Whitten, H. E.
Whitten, H. W.
Wilson, H. M.
Yaglou, C. P.

Boxborough—
Matthews, C. R.

Brighton—
Schanze, A. G.

Cambridge—
Baker, R. H.
Chaisson, C. H.
Cox, C. J.
Flint, C. T.
Haddock, I. T.
Heath, F. R.
Klonower, A. A.

Charlestown—
Herrick, D. A.

Dorchester—
Brown, M.
Hosterman, C. O.
Plunkett, J. H.
Swan, T. J.

Fitchburg—
Dolan, W. H., Jr.
Illig, W. R.
Karlson, A. F.

Framingham—
Fitch, W. S.
Nason, G. L.

Hyde Park—
Ellis, F. R.
Scheibel, A. H.

Lawrence—
Bride, W. T.

Leominster—
Kern, R. T.

Lynn—
Feehan, J. B.
Morgan, F. H.
Pool, S. H.
Reardon, J. A.

Malden—
McDonald, J. J.

Mattapan—
Mitchell, C. H.

Medford—
Dane, I. S.
Suits, G. A.

Melrose—
Pierce, E. F., Jr.
Smallman, E. W.

Newton—
Cousens, W. S.

Newtonville—
Jones, W. T.
McMurrer, L.

North Adams—
Buck, L.

Pittsfield—
Robbins, L. G.

Reading—
Florence, W. E., Jr.

Roxbury—
Richard, I. T.

South Weymouth—
Berchtold, E. W.

Watertown—
Wiegner, H. B.

Wellesley Hill—
Gilling, W. F., Jr.

West Newton—
Place, H. R.

Weymouth—
Clough, L.

Woburn—
Parker, P.

Wollaston—
Hodgdon, H. A.

Worcester—
Dix, H. M.
Hawes, H. R.

MICHIGAN

Ann Arbor—
Backus, T. H. L.
Cuthbert, I. N.
Emswiler, Prof. J. E.
Hutzel, A. F.

Detroit—
Armstrong, H. M.
Baker, C. H.
Baldwin, W. H.
Bishop, F. R.
Blackmore, F. H.
Boales, W. G.
Brender, P. E.
Brown, W. C.
Clark, E. H.
Collamore, R.
Connell, R. F.
Coon, T. E.
Cummings, C. A.
Cummins, G. H.
Dauch, E. O.
Davis, L. J.
Decker, E. M.
Degan, J. E.
Dillman, E. J.
Donahue, E. S.
Doody, C. A.
Dubry, E.
Eggleston, L. W.
Emerick, S. H.
Fuller, J. L.
Gallaher, J. E.
Giguere, Geo. H.
Goss, M. H.
Green, J. E.
Hamlin, H. A.
Harms, W. T.
Harrigan, E. M.
Heydon, C. G.
Hill, N. J.
Hillman, R. W.
Hoffman, C. F.
Hogan, E. L.
Hubbard, N. B.
Hughson, H. H.
Johnson, F. W.
Johnson, H. S.
Johnston, W. B.
Killian, M. A.
Knight, A. B.
Lance, J.
Linhard, H. V.
Little, E. R.
Locker, C. W.
McColl, J. R.
McConner, C. R.
McGeorge, R. H.
McIntire, J. F.
McLean, D.
McNair, E. E.
Marion, C. A.
Meyer, J. W., Jr.
Miller, J. F. G.
Milward, R. K.
Morgan, C. S.
Morse, C. T.
Paetz, H. E.
Parrott, L. G.
Partlan, J. W.
Peckham, R. R.
Phelps, H. R.
Pittelkow, A. G.
Purcell, F. C.
Purcell, R. E.
Randall, W. C.
Roney, T. G.
Rowe, W. A.
St. John, J. S.
Saulson, S.
Shuell, F. W.
Smith, G. W.
Smith, L. L.
Snell, E.

Snyder, J. W.
Soderberg, C. H.
Spitzley, R. L.
Spurgeon, J. H.
Stephen, H. M.
Verner, W. F.
Walker, J. H.
Walton, H. L.
Whelan, W. J.
Whiteley, J.
Wigle, B. M.
Wilde, R. S. M.
Williamson, A. H.
Wooley, T. R.
Ziel, H. E.
Zorb, H. P.

Dowagiac—
Firestone, J. F.

Flint—
Titus, M. S.

Grand Rapids—
Alexander, C. H.
Bradfield, W. W.
Carman, G. G.
Carroll, W. J.
Hepburn, G. V.
Jaynes, E. L.
Miller, H. N.
Waters, G. G.

Grosse Pointe—
McConachie, L. L.

Highland Park—
Foster, W. M.

Holland—
Cherven, V. W.

Kalamazoo—
Blaney, C. A.
Kersjes, W.
Monroe, L. O.

Lansing—
Distel, F., Jr.

Pleasant Ridge—
Blessed, W. A.
Petherick, D. H.

Pontiac—
Schildmiller, G. H.

Saginaw—
Swartwout, J. D.

MINNESOTA

Cloquet—
Backstrom, E. R.
Spafford, A.

Duluth—
Foster, C.
Whitnah, C. S.

Minneapolis—
Andresen, A. W.
Barnum, M. C.
Betts, H. M.
Bjerken, M. H.
Bradford, H. H.
Brown, J. H.
Burns, E. J.
Burritt, C. G.
Cash, T. T.
Challman, S. A.
Cowles, B. E.
Dahlstrom, G. A.
Forfar, D. M.
Gerrish, H. E.
Gordon, E. B., Jr.
Hanchett, J. H.
Harris, J. B.
Hasey, C. E.
Helstrom, H. G.
Huch, A. J.
Martenis, J. V.
Mikesh, J. J.
Morgan, G. C.
Mosher, R. B.
Probst, A. H.
Rockert, E. R.
Rowley, F. B.
Sanford, A. L.
Sperzel, H. J.
Uhl, E. J.
Uhl, W. F.
Zingsheim, G. G.

Owatonna—
Clarkson, W. B.

St. Paul—
Anderson, P. E.
Buenger, A.
Gausman, C. E.
Heagler, J. M.
Jones, E. F.
Lewis, E. B.
Otto, R. W.
Parks, W. N.
Ruff, D. C.
Skagerberg, R.
Wagner, A. M.
Winterer, F. C.
Wunderlich, M. S.

MISSISSIPPI

Jackson—
Paine, K. A.
Peters, H. G.

MISSOURI

Independence—
Cook, B. F.

Kansas City—
Arthur, J. M., Jr.
Betz, H. D.
Burton, C. A.
Caleb, D.
Campbell, E. K.
Carr, C. H.
Clegg, Carl
Cox, W. F.
Dodds, F. F.
Downes, N. W.
Dunlap, R. L.
Fehlig, J. B.
Gillham, W. E.
Gorton, G. H.
Griffin, F. A., Jr.
Hall, T.
Henrici, H. C.
Herold, C. W.
Hitchcock, F. P.
Jones, E.
Joyce, W. P.
Kitchen, F. A.
Kitchen, J. H.
Lewis, J. G.
Mason, R. B.
Millis, L. W.
Natkin, B.
Naylor, B. C.
Nottberg, H.
Painter, D. H.
Pensinger, L. C.
Pines, S.
Qualtrough, B. F.
Plass, C. W.
Sheppard, F. A.
Stephenson, L. A.
Weiss, C. A.
Wise, F. W.
Woodling, M. D.
Worm, A.
Wright, H. H.

Kirkwood—
McMorran, F. J.

Liberty—
Dudfield, A.

St. Louis—
Baetz, H.
Balsinger, H. D.
Barnes, E. R.
Baumgardner, C. M.
Bayse, H. V.
Bowers, J. S.
Bradley, E. P.
Bradley, J. T.
Branigin, H. L.
Browning, H. K.
Buder, C. G.
Butler, C. W.
Cook, C. D.
Cooper, J. W.
Davis, C. R.
De Nellie, J. L.
Edwards, D. F.
Eichler, A.
Evleth, E. B.
Falvey, J. D.
Ferguson, R. R.
Foster, J. M.
Gale, T. J. C.
Gallaher, A. J.
Graves, R. E.
Hallett, E. S.
Halley, W. H.
Harris, H. W.
Helwig, G. A.
Hester, T. J.
Humphreys, A. E.
Kaysing, H. C.
Keiser, W.
Lane, A. M.
Langenberg, E. B.
Manahan, J. E.
Meara, J. J.
Merrell, S. A.
Messmer, G. E.
Moon, L. W.
Niestrath, W. H.
Picker, F. C.
Pickett, C. A.
Quentin, E. H.
Rickly, F. A.
Robertson, J. M.
Rosebrough, R. M.
Rossman, V. D.
Russell, W. L. A.
Sachleben, E. H.
Schukai, W. C.
Schulze, B. H.
Sodemann, P.
Sodemann, W. C.
Stack, M. F.
Stammer, E. L.
Steckhan, L.
Thomsen, W. T.
Walters, A. L.
White, E. A.
Wolff, O. H.

Springfield—
Cooper, H.

Webster Groves—
Chappell, R. E.

MONTANA

Billings—
Cohagan, C. C.
Tooker, C. C.

Bozeman—
Powers, F. I.

Helena—
Bain, J. G.

NEBRASKA

Omaha—
McCulley, D. E.

Scottsbluff—
Davis, O. E.

NEW JERSEY

Atlantic City—
Monday, C. E.
Strouse, S. B.

Audubon—
Lynch, G.

Bloomfield—
Hochuli, H. W.
Lau, A. S.

Bogota—
Heebner, W. M.

Caldwell—
Oswald, W. L.

Camden—
Kappel, G. W. A.
Kohr, R. K.
Lanning, E. K.
Rugart, K.
Strandwitz, W. J.
Swift, C. K.
Webster, E. K.
Webster, W.
Webster, W., Jr.

Cranford—
Terrell, H. A.

East Orange—
Bolling, Esten
Grahn, V. F.
Merkel, F. P.
Schroth, A. H.
Turno, W. G. W.

Elizabeth—
Cornwall, G. T.
Nesdahl, E.
Pearce, C. E.
Wheller, H. S.

Essex Fells—
Carrier, W. H.
Stacey, A. E., Jr.

Fair Haven—
Smith, H. P.

Glen Ridge—
Chapman, F. T.

Glen Rock—
Hall, C. H.

Grantwood—
Butler, P. D.

Haddonfield—
Dobbs, C. E.
Jones, R. E.

Hasbrouck Heights—
Goodwin, S. L.

Hawthorne—
Lawton, F. C.

Irvington—
Freas, R. B.
Wells, H. N.

Jersey City—
Calahan, J. J.
Driscoll, W. H.
Jones, H. L.
Ritchie, W.
Walterthum, J. J.

Jobstown—
Allinson, O. H.

Kearney—
Long, D. R.
Siebs, C. T.
Vogelbach, O.

Loch Arbour—
Tomlinson, M.

Lyndhurst—
Ehrlich, M. W.

Maplewood—
Evans, W. A.
Smith, M. S.

Merchantville—
Binder, C. G.

Montclair—
Holbrook, F. M.

Newark—
Bentz, H.
Bermel, A. H.
Binder, I.
Connolly, C. I.
Heiles, F. C.
Hunt, P. M.
Janet, H. L.
Lewis, L. L.
Lyle, J. I.
McCormick, E. T.
Noble, M.
Soule, L. C.
West, Perry
Worsham, H.

Nutley—
Matthiessen, H. G. F.

Oaklyn—
Driggs, L. L.

Palmyra—
Schopp, W. J.

Passaic—
Boeker, C. H.
Hankin, R.
Harding, R. M.
Morris, C. R.

Paterson—
Pryor, F. L.

Plainfield—
MacDougall, B. W.
Rech, P. D.
Tobin, G. J.

Princeton—
Black, J. J.

Riverton—
Bilyeu, W. F.
Brunt, T. B.

Rutherford—
Davidson, R. A.

Short Hills—
Fouilhoux, J. A.

South Orange—
Hansen, C. C.

Summit—
Kimball, W. C.

Trenton—
Piper, A.
Perlstein, S.

Union City—
Darton, A. W.
Taverna, F. F.
Thuem, E. A.

Verona—
Frutchey, M. P., Jr.

West New York—
Ricker, J. J.

NEW YORK

Albany—
Murray, T. F.
Naden, L. J.
Ryan, H. J.
Steim, C. J., Jr.
Stevens, F. H.
Taggart, R. G.

Binghamton—
Folley, E. B.

Bronxville—
Barr, G. W.

Brooklyn—
Atwater, L. W.
Bampton, C. M.
Beatty, D. J.
Bender, C. P.
Bennett, I. T.
Blest, F. S.
Bondy, W. S.
Chadeayne, G. D.
Crutchley, E., Jr.
Dalto, F. J.
DePalma, J. R.
Doherty, J. A.
Dwyer, T. F.
Dyer, W. S.
Fells, H. B.
Emery, W. D.
Gardner, B. F.
Gornston, M. H.
Griffin, B. H.
Hanley, J. H., Jr.
Harrison, B. S.
Hinchman, E. G.
Kreitner, W.
London, I.
McCann, F. G.
Mandeville, E. W.
Moss, E.
Musaus, J., Jr.
Phillips, F. W., Jr.
Richardson, F. J.
Ruppert, E. H.
Scollay, U. G.
Seward, P. H.
Shay, R. A.
Siegel, L.
Tisnower, W.
Tusch, W.
Vivarttas, E. A.
Walsh, J. F.
Ward, G. C.
Williamson, F. W.

Buffalo—
Ahlff, A. L.
Archer, F. S.
Beirn, J. U.
Beman, M. C.
Booth, C. A.
Breneman, R. B.
Bresnahan, J. J.
Bulkeley, C. A.
Burke, F. H.
Castin, L. N.
Cherry, L. A.
Cheyney, C. C.
Chittenden, F. J.
Clucas, W. F.
Criqui, A. A.
Danforth, N. L.
Davis, J.
Dempsey, H. P.
Drake, G. H.
Dyer, O. K.
Evans, C. A.
Ewing, D. R.
Farnham, R.
Farrar, C. W.
Frank, O. E.
Frankel, G.
Fraser, W. G.
Gauvin, L. G.
Harding, L. A.
Hedley, P. S.
Jackson, M. S.
Johnson, E. E.
Ingels, M.
Landers, J. J.
Love, C. H.
Madison, R. D.
Mahoney, D. J.
Monin, E. H.
Moran, R. J.
Mosher, C. H.
Novotney, T. A.
Padginton, G.
Quigley, W. J.
Roebuck, Wm., Jr.
Rooney, M. A.
Ruckel, J. B.
Schank, G. E.
Scheer, F. W.
Snyder, J. S.
Stearns, W. F.
Thornton, R. T.
Tinker, A. K.
Wendt, E. F.
Wendt, H. W.
Wright, J. C.
Yager, J. J.

Elmira—
Davis, B. C.
Frutchy, A. E.
McGlenn, G. R.
Roberts, J. H.

Geneva—
Herendeen, F. W.
Smith, S. S.

Glens Falls—
Robinson, A. G.

Herkimer—
Ertman, B. R.

Irondequoit—
Haskins, A. L.

Irvington-on-Hudson—
Bastedo, A. E.
Kittle, F. C.

Ithaca—
Sawdon, W. M.
Williams, J. W.

Kenmore—
Bliss, S. C.
Riley, D. H.
Smith, J. C.

Larchmont—
Gaylor, W. S.

Middletown—
Sanborn, S. H.

Millbrook—
Pizie, S. G.

Morton—
Stangland, B. F.

Mt. Vernon—
Hiers, C. R.
Hunt, R. B.
Obert, C. W.

New Rochelle—
Dailey, J. F.
Kuhlmann, R.
Senior, R. L.

New York City—
Abrams, A.
Addams, H.
Adler, A. A.
Alvord, A. M.
Ames, C. F.
Armagnac, A. S.
Bachler, L. J.
Baird, F. X.
Barth, H. E.
Baum, A. L.
Beebe, F. E. W.
Bennitt, G. E.
Berman, L. K.
Birch, H. R.
Bishop, C. R.
Blackman, A. O.
Blackmore, J. J.
Bock, B.
(St. Albans, L. I.)
Bolton, R. P.
Booth, H. N.
Brassington, A. F.
(Port Richmond, S.I.)
Browne, A. L.
Brunner, H.
Buensod, A. C.
Campbell, F. B.
Carpenter, R. H.
Carty, T.
Chase, J. M.
Clark, W. D.
(Richmond Hill, L. I.)
Cosgrove, W. M.
Crone, T. E.
Cumming, R. W.
Dailey, J. A.
Darts, J. A.
Davis, A. C.
Day, V. S.
Dill, H. O.
Donnelly, R.
Donnelly, W.
(Lynbrook, L. I.)
Donoghue, J. J.
Dornheim, G. A.
(L. I. City)
Downe, E. R.
Duff, K.
Duffield, T. J.
Durand, W. L.
Eadie, J. G.
Easterbrooks, C. C.
Eastwood, H. F.
Ellis, W. H.
Ellison, J. H.
(Freeport, L. I.)
Ely, F. E.
Emerson, R. R.
Engle, A.
Fansler, P. E.
Faulkner, D. H.
Fay, F. C.
Feldman, A. M.
Fiedler, H. W.
Fleisher, W. L.
Flemming, W. L.
Fletcher, S. W.
Flink, C. H.
Forgan, D. M.
Forgee, F. A.
Friedman, A.
Gast, C.
Glore, E. F.
Goldberg, H. M.
Goldschmidt, O. E.
Gombers, H. B.
Goodnow, W. F.
Grant, A. E.
Grill, G. E.
Harbula, M. G.
Heatherton, J. M.
Hedges, H. B.
Hettinger, H.
(Long Island City)

Heymsfield, H. R.
Hills, A. H.
Hinkle, Edwin C.
(Hempstead, L. I.)
Hinrichsen, A. F.
Hoffman, C. S.
Hook, M. G.
Howell, F. B.
Hubert, J. W.
Hunter, H. R.
Hyman, W. M.
Hynes, L. P.
Ireland, T. H.
(Rockville Center, L.I.)
Issertell, H. G.
Jacobus, Dr. D. S.
Jalien, J. J.
Johnsen, H.,
(New Brighton, S.I.)
Johnson, E. B.
(W. New Brighton, S. I.)
Johnston, W. H.
Keasbey, A. P.
Keenan, P. F.
Kellogg, T. M.
Kiewitz, A. A.
(L. I. City)
Kimball, D. D.
Kingsley, E. A.
Kirk, L. G.
Klaus, L. J.
(Farmingdale, L. I.)
C. Kiewitz
(Floral Park, L. I.)
Knowles, A. F.
Koithan, W. S.
LeBeau, J. F.
LeCompte, W. G.
Lemmerman, C. W.
Linderman, H.
(Ridgewood, L. I.)
Longwell, H. E.
Lucke, C. E.
Lyle, E. T.
McKiever, W. H.
McMahon, W. W.
McMillan, L. B.
Maier, G. M.
Marshall, H. H.
Martin, G. W.
Meyer, H. C., Jr.
Mickiewics, S. J.
Miller, C. A.
Miller, E. A.
Miller, R. B.
Morrill, R. D.
Munder, J. F., Jr.
Munier, L. L.
Munro, E. A.
Murphy, E. T.
Murphy, J. R.
(Kew Gardens, L. I.)
Murphy, W. A.
Neale, L. I.
Neideck, A. A.
Nelson, G. A.
Nicol, N. C.
Oaks, O. O.
O'Connell, M. E.
O'Donnell, T. J.
Odrobina, S. R.
(Long Island City)
Offner, A. J.
Olvany, W. J.
Osborn, W. J.
Parkhill, D.
Parter, S. C.
Patorno, S. A. S.
Paulding, L. G.
Peacock, J. K.
Pease, H. H.
Petersen, G.
Pfeiffer, B. J.
Pfuhler, J. L.
(W. New Brighton, S. I.)
Pihlman, A. A.
Pinder, P. H.
Place, C. R.
Pryor R. W., Jr.
Purdy, R. B.
Purinton, D. J.
Quirk, C. H.
Raisler, L.
Raisler, S.
Ralston, L. T. M.
Reed, J. F.
Reynolds, T. W.
Reynolds, W. V.
Riblet, W. H.
Richardson, D. R.
Riley, C. L.
Ritchie, E. J.
Ritter, A.
Rodman, R. W.
Rosenberg, P.
Ross, J. O.
Ruggles, R. F.,
(Tompkinsville, S. I)
Russell, W. A.
Ryndell, C. A.
Samuels, S.
Sawade, C. A.
Schloss, N. L.
Schmidt, G. G.
Schneider, C.
Schoepflin, P. H.
Scott, C. E.
Scott, E. A.
Scott, G. M.
Seelig, A. E.
Sellman, N. T.
Simpson, W. A.
Sklenarik, L.
(Long Island City)
Smith, P. C.
(Northport, L. I.)
Snyder, C. B. J.
Spooner, H. R.
(Hollis, L. I.)
Stanton, G. W.
Staples, W. H.
Steinke, G. B.
Steinmuller, J. H.
(Long Island City)
Stern, H. R.
Sternberg, I. E.
Stewart, C. W.
Still, F. R.
Sullivan, D. A.
Swain, W. A.
Sweeney, S. H.
Tallmadge, W.
Taylor, J. H.
Thomson, T. N.
(Huntington, L. I.)
Timmis, W. W.
(Glen Cove)
Tucker, F. N.
Van Norden, E. M.
Vogt, J. H.
Walker, W. K.
Wallace, G. J.
(E. Elmhurst, L. I.)
Walsh, J. H.
Walsh, M.
Watters, P. J.
(Port Richmond, S. I.)
Waechter, H. P.
(Tompkinsville, S. I.)
West, B. F.
White, E. S.
White, M. G.
Whitelaw, H. L.
Willis, R. C.
Wilson, F. A.
Wolff, R. A.
Wolfsfeld, C. F.
(Bayside, L. I.)
Worth, W. E.
Wright, C. L.

North Tarrytown—
Weiss, A. P.

N. Tonawanda—
Kline, W. J.
Slade, A. J.

Ogdensburg—
Skelly, J. F.

Port Chester—
Pratt, E. D.

Poughkeepsie—
Doherty, J. J.
Valentine, H. D.

Rochester—
Axeman, J. E.
Beasom, G. R.
Coe, I. B.
Coe, R. T.
Devendorf, W. F.
DeWolf, R. D.
Dobson, G. G.
Sheldon, N. E.
Weider, F. J.
Welsh, H. S.
Wilder, E. L.
Wiley, C. S.

Rome—
Lynch, W. L.

Rye—
Donovan, J.

Saranac Lake—
Miller, P.

Scarsdale—
Grotz, A. B.

Schenectady—
Harbison, E. J.
Strachan, J. S.
Vogel, A.

Snyder—
Langley, F. P.

Syracuse—
Acheson, A. R.
Bradley, R. H.
Dennis, C. K.
Duncan, J. M.
Gildea, T. E.
Ormsby, H. K.
Ryen, M.

Tarrytown—
Grossman, H. E.

Tuckahoe—
Nichols, G. B.

Troy—
Wilson, C. H.

Utica—
Brandeles, H. J.
Cantwell, W. T.
DeRosa, A.
Hamjy, P. W.
Hughes, W. C.
Schneider, P. W.
Steinhorst, T. F.

Wanakah, Erie Co.—
Kamman, A. R.

West Point—
Bryant, P. J.

White Plains—
Callahan, T. H.

Yonkers—
Brabbee, Dr. C.
Goerg, B.
Kelly, J. G.
Newcomb, R.
Rainger, W. F.
Ullman, H. G.
Zuhlke, W. R.

NORTH CAROLINA

Charlotte—
Brandt, E. H., Jr.
Christian, C. W.
Hackney, H.

Greensboro—
MacKenzie, B.

Weldon—
Chappell, T. A.

Winston-Salem—
Bahnson, F. F.

OHIO

Akron—
Humphrey, D. E.
McClenathan, R.
Thatcher, G. S.
Tyson, W. H.

Cincinnati—
Blomfeldt, A. A.
Bostain, J. C.
Cuyler, D. H.
Doyle, W. J.
Green, W. C.
Grier, W.
Houliston, G. B.
Kiefer, C. J.
Kitchell, H. N.
Rehling, H. F.
Royer, E. B.
Sproull, H. E.
Wright, K.

Cleveland—
Adrianse, P. R.
Arthur, H. W.
Benedict, E. R.
Beyer, J. E.
Bridges, F. G.
Brueggeman, A. R.
Colby, C. W.
Deex, C. J.
Eveleth, C. F.
Farley, J. W.
Gottwald, C.
Greene, W. C.
Harrison, J. M.
Harvey, L. C.
Jackson, T. L.
Herske, A. R.
Kinner, J. E.
Kissick, J. J.
Klie, W.
McLeish, W. S.
Mason, J. J.
Matzen, H. B.
Miles, J. C.
Neitzel, C. W.
Quay, D. M.
Rather, M. F.
Roemer, J.
St. Clair, C. W.
Stackhouse, R. M.
Starks, V. E.
Van Sickle, W. B.
Weager, T. A.

Cleveland Heights—
Davis, R. G.
Heinle, E. L.

Columbus—
Babbitt, E. C.
Brown, A. I.
Fleming, R. A.
Selders, J. T.
Wheeler, O. J.
Williams, A. W.

Dayton—
Gibbons, M. J., Jr.
Haas, W.
Hoersting, F. J.

East Cleveland—
Nobis, H. M.
Stark, W. E.

Kent—
Stanford, L. E.

Lakewood—
Kammerer, W. C.
Maurer, E. D.

Lorain—
Lane, E. K.

Mansfield—
Barnsteiner, A.

Painesville—
Hobbs, J. C.

Ravenna—
Franzheim, G. W.

Springfield—
Hart, T. H.

Toledo—
Baker, H. C.
Bryce, S. D.
Holmes, J.
Rogers, A. C.

Warren—
Lyman, W. I.

Youngstown—
Choffin, C. C.

OKLAHOMA

Oklahoma City—
Butler, C.
Dolan, R. G.
Loeffler, F. X.
Patton, R. L.
Rae, T. W.
Thomas, B. A.

Tulsa—
Jones, E.

OREGON

La Grande—
Anderson, S. A., Jr.

PENNSYLVANIA

Allentown—
Buel, H. G.
Hersh, G. W.
Korn, C. B.

Ambridge—
McCreary, J. L.

Ardmore—
Graham, C. D.
Haynes, C. V.
Hires, J. E.
Myers, G. W. F.
Whelan, W. F.

Beaver Falls—
Van Alen, W. T.

Boyertown—
King, T.

Bradford—
Goodloe, A. M.
Paterson, F. C.

Bridgeport—
Abel, D. M.
Holton, J. R.
Longenecker, H. J.

Cannonsburg—
Edwards, C. H.

Chambersburg—
Kottcamp, H. A.
Mehaffey, W. C.

Chester—
Boyd, W. R.

Drexel Hill—Del. Co.
Jones, L. T.
Kriebel, J. H.
Miller, A. A.
Rice, W. W.

Erie—
Gannon, J. E.
Mayer, R. S.

Germantown—
Huckel, F., Jr.

Glenshaw—
McElroy, G. S.

Harrisburg—
Eicher, H. C.
Filson, F. E.
Fisher, E. L.
Geiger, I. H.
Gray, W. E.
Koehler, G. T.
Lutz, J. H.
Schimmel, F. W.
Selig, E. T.

Haverford—
Black, E. N.

Hazelton—
Sherry, R. W.

Holmesburg Junction—
Nesbitt, A. J.
Nesbitt, J. J.

Johnstown—
Desparois, L. D.
Dillon, H. R.
Rinkenberger, G.

Lancaster—
Grossman, H. M.
Huzzard, E. C.
Jones, A.
Schrader, C. C.
Vaux, F. J.

McKeesport—
Dugan, T. M.

Merion—
Myers, D. R.

Narberth—
Timmis, P.

New Castle—
Eckles, R. A.

Norristown—
Frost, R. V.
Gormly, J.
Gormly, P.
Hucker, J. H.

Oil City—
Heagerty, W. H.

Philadelphia—
Adams, B.
Alt, H. L.
Anderson, C. A.
Arnold, R. S.
Bachler, H. C.
Bartlett, C. E.
Bauer, H. C.
Beahm, R. B., 2nd
Black, H. G.
Blankin, M. F.
Bogaty, H. S.
Bolsinger, R. C.
Boon, G.
Bornemann, W. A.
Boyd, D. K.
Braemer, W. G. R.
Breen, J. W.
Brogan, J. J.
Burt, J. E.
Carey, J. A.
Carstens, E.
Cassell, J. D.
Cavileer, J. V.
Clarkson, R. C., Jr.
Cooper, T. W.
Culbert, W. G.
Dambly, A. E.
Davidson, L. C.
Davidson, P. L.
Dome, W. R.
Doud, M. P.
Duemler, F. C.
Eagan, W. H.
Eakins, W.
Eckardt, C. A. T.
Edgar, A. C.
Feltwell, R. H.
Fest, L. T.
Fitz, J. C.
Fleming, T. C.
French, D. E.
Galligan, A. B.
Galligan, J. H.
Gant, H. P.
Gaulin, R. P.
Gilbert, M. F.
Gillett, M. C.
Glassey, J. W.
Gomersall, W. H.
Hackett, H. B.
Hellerman, H. H.
Hess, H. L.
Hetherington, E. T.
Hibbs, F. C.
Hirst, J. N.
Hoben, R. J.
Hoft, P. J.
Hopkin, W. E.
Houpt, G. A.
Hunger, R. F.
Hurley, J. C.
Ickeringill, J.
Jellett, S. A.
John, B. F.
Johnson, J. M.
Kappler, H. C.
Kauffman, R.
Kelbe, F. R.
Kellogg, H. D.
Kerney, T. F.
Keys, G. W.
Kipe, J. M.
Koch, H. O.
Kriebel, A. E.
Leahy, J. L.
Lewis, G. C.
Lewis, J. W.
Lewis, T.
Liner, J. J.
Locke, H. W.
Lord, F. R.
Lyman, S. E.
McCarthy, C. J.
McClintock, A., Sr.
McClintock, A., Jr.
McClintock, J. L.
McHugh, G. F.
McLaughlin, J. J.
MacDade, A. H.
Matson, T.
Mellon, J. T. J.
Mensing, F. D.
Mervine, T. R.
Meyer, R. C.
Miller, H. F.
Miller, W. C.
Minnich, H. S.
Morgan, R. C.
Mott, A. C., Jr.
Murphy, W. R.
Nelson, F., Jr.
Norris, J. C.
Nussbaum, L.
O'Connell, E. D.
Ogelsby, W. P.
Paine, L. G.
Patterson, D. F.
Peak, A. M.
Pennell, S. H.
Perkins, F. C.
Phillips, F. T.
Plewes, S. E.
Ramsay, H. W.
Reilly, C. E.
Reuss, E. H., Jr.
Roberts, H. L.
Rothrock, J. T.
Sabin, E. R.
Sanbern, E. N.
Scott, C. E.
Setzer, W. C.
Sewell, J. M.
Sheffler, M.
Sommer, L. J., Jr.
Speckman, C. H.
Stearns, W. I.
Stone, G. F.
Strong, R. C.
Sutterley, W. W.
Taliaferro, R. R.
Thompson, J.
Thompson, W. P.
Tinker, W. E.
Tyler, R. D.
Wagner, J. P.
Walther, H. J.
Wandless, F. W.
Ward, L. T.
Wegmann, A.
Welamb, V. N.
Whitby, S. S.
Why, H. B.
Wild, W. H.
Wilmot, C. S.
Wilson, B. W.
Wilson, J. J.
Woolston, A. H.
Woolston, C. E.

Pittsburgh—
Aston, J.
Beighel, H. A.
Blackmore, G. C.
Blackmore, N. L.
Bowman, H. A.
Brauer, R.
Bushnell, C. D.
Chester, T.
Clark, F. C.
Clark, W. H.
Comstock, G. M.
Dibble, S. E.
Edwards, P. A.
English, A. T.
Evans, E. C.
Firsching, F. J.
Gunther, F. A.
Hanson, E. W.
Harper, S. H.
Heilman, R. H.

Hook, C. H.
Houghten, F. C.
Langdon, J. D.
Lloyd, E. C.
McGinness, J. E.
McGuigan, L. A.
McIntosh, F. C.
McMurray, J.
Maginn, P. F.
Moore, H. L.
Morgan, J. S.
Morrow, C. F.
Nass, A. F.
Nicholls, P.
O'Neill, P.
Orr, H. B.
Rederer, B. S.
Richards, S. F.
Schley, A. A.
Speller, F. N.
Stanger, R. B.
Stevenson, W. W.
Stitt, E. W.
Stokes, R. E.
Waldron, C. W.
Walker, J. B.
Weber, G. A.
Wheeler, C. W.
Williams, O. L.
Zelditch, M.

Reading—
Luck, A. W.
Nicely, J. E.
Reese, H. L.

Ridley Park—
Davis, B. W.

Scranton—
Gilboy, J. P.
Saville, T. H.
Walker, G. F.

Sewickley—
Black, G. E.

Shamokin—
Gortner, J. W.

South Williamsport—
Koltz, A. W.

Stroudsburg—
Kiefer, E. J., Jr.

Swissvale—
Timmerman, M. M.

Tamaqua—
Hadesty, A. L., Jr.

Upper Darby, P. O.—
Hackett, C. P.

Warren—
Schellhammer, A. L.

Washington—
McVehil, E. W.

Wayne—
Iddles, A.

Wilkinsburg—
Campbell, T. F.
Rasmussen, E.

Williamsport—
Chambers, W. E.
McLain, R. D.
Moltz, G. N.
Pfeiffer, J. F.

Willow Grove—
Slight, I.

Wormleysburg—
Miller, T. G.

York—
Hertzler, J. R.
Lindemuth, N. R.
Sowers, P. E.

Zelienople—
Eberle, C. F.

RHODE ISLAND

Pawtucket—
Martin, J. F.

Providence—
Coleman, J. B.
Dunlevy, T. R.
Gibbs, E. W.
Hartwell, J. C.
Husband, E. W.
McLaughlin, J. D.
Moulder, A. W.
Poole, E. F.

Washington—
Wilson, H. A.

TENNESSEE

Chattanooga—
Russell, H. C.

Memphis—
Allen, W. H.
Bevil, A. T.
Brewster, D. R.

Nashville—
Brown, F.
Hailey, S. H.

TEXAS

Amarillo—
Helphingstein, O.

College Sta.—
Giesecke, F. E.

Dallas—
Parks, V. H.
Taylor, R. F.
Van Zandt, J. H.

Fort Worth—
Burnett, E. S.
Skinner, H. W.

Houston—
Barnes, A. F.

San Antonio—
Diver, M. L.
Ebert, W. A.
Reynolds, H. M.
Willis, W. J.

UTAH

Salt Lake City—
Cooper, A. W.

VERMONT

Burlington—
Austin, F. L.
Raine, J. J.

N. Ferrisburg—
Breckenridge, L. P.

St. Albans—
Sturges, H. A.

VIRGINIA

Lynchburg—
Cleland, J. E.
Doering, F. L.
Wiley, E. C.
Wilson, E. J. F.

Newport News—
Noland, L. U.

Norfolk—
Montagna, C. J.
Peebles, J. K.
Wilson, E. K.

Richmond—
Austin, W. E.
Beverley, R. C.
Carle, W. E.
Childress, W. L.
Johnston, J. A.
Livingston, B. B.
Schulz, H. I.

Roanoke—
Wash, W. P.

Staunton—
Moffett, W. S.
Moran, F. N.

WASHINGTON

Seattle—
Beggs, W. E.
Brasch, H. K.
Brown, A. P.
Carsten, W. H.
Cox, W. W.
Dudley, W. L.
Early, G. D.
Eastwood, Prof. E. O.
Eckart, C. H.
Godfrey, F. H.
Heath, S. C.
Mallis, W.
Mann, C. P.
O'Connell, P. M.
Ruddell, W. H.
Twist, C. F.
Weber, E. L.
Zokelt, C. G.

Spokane—
DeLong, H. B.
Nelson, R. L.

Yakima—
McCune, B. V.

WEST VIRGINIA

Charleston—
Meyers, S. H.
Shanklin, J. A.
Shanklin, J. R.

Largent—
Donnelly, J. A.
Innis, H. R.

Morgantown—
Zeck, A.

Wheeling—
Hare, E. S.
Schofield, T. J.

WISCONSIN

Eau Claire—
Grosvold, F. E.

Fond Du Lac—
Ahern, T. L.

Fort Atkinson—
Shodron, J. G.

La Crosse—
Anderegg, R. H.
Johnson, T. R.
Miller, M. W.
Trane, R. N.

Madison—
Larson, G. L.
Plaenert, A. B.
Richtmann, W. M.

Milwaukee—
Berghoefer, V. A.
Berringer, S. H.
Bowers, A. F.
Brown, W. H.
Cook, H. R.
Dannies, F. R.
Downey, F. E.
Downey, P. C.
Ellis, H. W.
Goethel, A. C.
Grassler, E.
Jackson, C. H.
Jones, E. A.
Jung, J. S.
Juttner, O. J.
Knab, E. A.
Lovegren, H. M.
Meadows, F. H.
Miller, C. W.
Miller, H. M.
Mueller, P. E.
Noll, W. F.
Olson, R. G.
Ostrander, L. F.
Randolph, C. H.
Schwab, H. E.
Ver Halen, E. T.
Volk, J. H.
Weimer, F. G.
Wilson, W. H.
Wolf, J. C.
Worthing, E.

Oshkosh—
Paterson, G. E.

Racine—
Dixon, A. G.
Rice, C. J.
Thomas, N. A.

Superior—
Eddy, W. H.
Jarvis, G. E.

Wausau—
Bassler, E. M.

Wauwatosa—
Page, H. W.
Zuehlke, R.

West Allis—
Erickson, M. E.

Wisconsin Rapids—
Eron, L. J.

FOREIGN COUNTRIES

CANADA

Calgary, Alberta—
Clarke, S. S.
Walker, A.

Edmonton, Alberta—
Kelly, H.
Latham, G.

Galt, Ont.—
Evans, J.
McCaffrey, H. G.

Guelph—
Taylor, M. A.

Halifax, N. S.—
Eagar, R. F.

Islington, Ont.—
Wilson, G. T.

Kingston, Ont.—
Arkley, L. M.
Druce, J. J.

London, Ont.—
Colver, G. L.

Montreal, Que.—
Friedman, F. J.
Fry, J. D.
Higgins, T. J.
Kastello, A.
LaPrairie, C.
Linton, J. P.
McGrail, T. E.
Osborne, G. H.

Ottawa, Ont.—
Gray, G. A.

Quebec, Que.—
Dube, W.
Wiggs, G. L.

Sault Ste. Marie, Ont.—
Wilson, W. S.

Toronto, Ont.—
Addy, E.
Angus, H. H.
Birrell, A. L.
Blackhall, W. R.
Boddington, W. P.
Church, H. J.
Clifton, W. F.
Cole, G. E.
Dickey, A. J.
Dolan, E. M.
Flett, H. R.
Gaby, F. A.
Harrington, C.
Henion, H. D.
Leitch, A. S.
McHenry, R. W. M.
McMichael, P.
MacKenzie, J. J.
Millar, R. J.
Moore, H. S.
O'Neill, J. W.
Paterson, J. S.
Peterkin, S. M.
Playfair, G. A.
Purdy, A. K.
Shears, M. W.
Sheffield, E. B.
Sheppard, W. G.
Thomas, M. F.
Watson, M. B.
Wood, J. S.

St. John, N. B.—
Campbell, J. P.

Vancouver, B. C.—
Blake, A. H.
Givin, A. W.
Johnston, R. E.
Leek, W.
McCreery, H. J.

Victoria, B. C.—
Sheret, A.

Windsor, Ont.—
Pennock, W. B.
Storey, G. C.

Winnipeg, Man.—
Jones, B. G.
Kirk, C. D.
Mackie, J.

BELGIUM

Brussels—
Mautsch, R.

CHINA

Shanghai—
Cooper, T. R.
Doughty, C. J.
Hauss, C. F.
Loh, N.-S.
Merritt, C. J.
Portrude, W. M.

South Manchuria—
Katsumoto, E.

Tientsin—
Baker, H. W. H.

DENMARK

Copenhagen—
Reck, W. E.

Smedegade, Slagelse—
Ulrich, K. F.

ENGLAND

Hull—
Hill, E. G. T.

Leeds—
Jennins, H. H.

Leicester—
Nesbit, D. M.

Liverpool—
Atkinson, R. E.
Honiball, C. R.

London—
Barker, A. H.
Groom, S. L.
Herring, E.
Nobbs, W. W.
Russell, J. N.

Manchester—
Chadwick, J. B.
Yates, W.

Stockport—
Webb, J. M.

Sunderland—
Vaux, N.

Trowbridge—
Haden, G. N.
Haden, W. N.

York—
Fryer, F. G.

FRANCE

Paris—
Barre, L. S.
Beaurrienne, A.
Downe, H. S.
Modiano, R.

GERMANY

Dessau—
Junkers, H.

Stuttgart—
Klein, A. R.

IRELAND

Cork—
Barry, P. I.

JAPAN

Tokyo—
Fukui, K.
Kitaura, S.
Sekido, K.
Shinohara, S.
Shozo, S.
Yamasaki, K.

MEXICO

Yucatan—
Croft, T.

NEW ZEALAND

Dunedin—
Davies, G. W.

NORWAY

Christiania—
Tjersland, A.

RUSSIA

Petrograd—
Sakouta, M. L.

SOUTH AMERICA

Santiago, Chile—
Carrasco, S.

SWEDEN

Stockholm—
Theorell, H. G. T.

SWITZERLAND

Winterthur—
Meier, K.

PAST OFFICERS

AMERICAN SOCIETY *of* HEATING *and* VENTILATING ENGINEERS

1894

President — Edward P. Bates
1st Vice-President — Wm. M. Mackay
2nd Vice-President — Wiltsie F. Wolfe
3rd Vice-President — Chas. S. Onderdonk
Treasurer — Judson A. Goodrich
Secretary — L. H. Hart

Board of Managers
Chairman, Fred P. Smith
Henry Adams — A. A. Cary
Hugh J. Barron — James A. Harding
Edward P. Bates, *Pres.* — L. H. Hart, *Secy.*

Council
Chairman, R. C. Carpenter
Albert A. Cryer — Chas. W. Newton
F. W. Foster — Ulysses G. Scollay, *Secy.*

1895

President — Stewart A. Jellett
1st Vice-President — Wm. M. Mackay
2nd Vice-President — Chas. S. Onderdonk
3rd Vice-President — D. M. Quay
Treasurer — Judson A. Goodrich
Secretary — L. H. Hart

Board of Managers
Chairman, James A. Harding
Geo. B. Cobb — Ulysses G. Scollay
Wm. McMannis — B. F. Stangland
Stewart A. Jellett, *Pres.* — L. H. Hart, *Secy.*

Council
Chairman, R. C. Carpenter
Henry Adams — T. J. Waters
Edward P. Bates — Albert A. Cryer, *Secy.*

1896

President — R. C. Carpenter
1st Vice-President — D. M. Quay
2nd Vice-President — Edward P. Bates
3rd Vice-President — F. W. Foster
Treasurer — Judson A. Goodrich
Secretary — L. H. Hart

Board of Managers
Chairman, Wm. M. Mackay
Hugh J. Barron — Stewart A. Jellett
W. S. Hadaway, Jr. — Wiltsie F. Wolfe
R. C. Carpenter, *Pres.* — L. H. Hart, *Secy.*

Council
Chairman, A. A. Cary
Albert A. Cryer — B. F. Stangland
Wm. McMannis — J. J. Blackmore, *Secy.*

1897

President — Wm. M. Mackay
1st Vice-President — H. D. Crane
2nd Vice-President — Henry Adams
3rd Vice-President — A. E Kenrick
Treasurer — Judson A. Goodrich
Secretary — H. M. Swetland

Board of Managers
Chairman, R. C. Carpenter
Edward P. Bates — Stewart A. Jellett
W. S. Hadaway, Jr. — Wiltsie F. Wolfe
Wm. M. Mackay, *Pres.* — H. M. Swetland, *Secy.*

Council
Chairman, Albert A. Cryer
John A. Fish — James Mackay
Wm. McMannis — B. F. Stangland

1898

President — Wiltsie F. Wolfe
1st Vice-President — J. H. Kinealy
2nd Vice-President — A. E. Kenrick
3rd Vice-President — John A. Fish
Treasurer — Judson A. Goodrich
Secretary — Stewart A. Jellett

Board of Managers
Chairman, Wm. M. Mackay
Thomas Barwick — A. C. Mott
John A. Connolly — Francis A. Williams
Wiltsie F. Wolfe, *Pres.* — Stewart A. Jellett, *Secy.*

Council
Chairman, R. C. Carpenter
Henry Adams — W. S. Hadaway, Jr.
Albert A. Cryer — Wm. McMannis
Wiltsie F. Wolfe, *Pres.* — Stewart A. Jellett, *Secy.*

1899

President — Henry Adams
1st Vice-President — D. M. Quay
2nd Vice-President — A. E. Kenrick
3rd Vice-President — Francis A. Williams
Treasurer — Judson A. Goodrich
Secretary — Wm. M. Mackay

Board of Managers
Chairman, Stewart A. Jellett
B. H. Carpenter — Wm. Kent
A. A. Cary — Wiltsie F. Wolfe
Henry Adams, *Pres.* — Wm. M. Mackay, *Secy.*

Council
Chairman, R. C. Carpenter
John Gormly — Wm. McMannis
W. S. Hadaway, Jr. — B. F. Stangland
Henry Adams, *Pres.* — Wm. M. Mackay, *Secy.*

1900

President — D. M. Quay
1st Vice-President — A. E. Kenrick
2nd Vice-President — Francis A. Williams
Treasurer — Judson A. Goodrich
Secretary — Wm. M. Mackay

Board of Governors
Chairman, D. M. Quay
Wm. Kent, *Vice-Chm.* — D. M. Nesbit
R. C. Carpenter — C. B. J. Snyder
John Gormly — Wm. M. Mackay, *Secy.*

1901

President — J. H. Kinealy
1st Vice-President — A. E. Kenrick
2nd Vice-President — Andrew Harvey
Treasurer — Judson A. Goodrich
Secretary — Wm. M. Mackay

Board of Governors
Chairman, J. H. Kinealy
Wm. Kent, *Vice-Chm.* — John Gormly
R. C. Carpenter — C. B. J. Snyder
R. P. Bolton — Wm. M. Mackay, *Secy.*

1902

President—A. E. Kenrick
1st Vice-President—Andrew Harvey
2nd Vice-President—Robert C. Clarkson
Treasurer—Judson A. Goodrich
Secretary—Wm. M. Mackay

Board of Governors

Chairman, A. E. Kenrick

John Gormly, *Vice-Chm.*	J. H. Kinealy
R. C. Carpenter	C. B. J. Snyder
Wm. Kent	Wm. M. Mackay, *Secy.*

1903

President—H. D. Crane
1st Vice-President—Wm. Kent
2nd Vice-President—R. P. Bolton
Treasurer—Judson A. Goodrich
Secretary—Wm. M. Mackay

Board of Governors

Chairman, H. D. Crane

C. B. J. Snyder, *Vice-Chm.*	A. E. Kenrick
R. C. Carpenter	Geo. Mehring
John Gormly	Wm. M. Mackay *Secy.*

1904

President—Andrew Harvey
1st Vice-President—John Gormly
2nd Vice-President—Robert C. Clarkson
Treasurer—Ulysses G. Scollay
Secretary—Wm. M. Mackay

Board of Governors

Chairman, Andrew Harvey

John Gormly	H. D. Crane
Robert C. Clarkson	A. E. Kenrick
J. J. Blackmore	C. B. J. Snyder
R. C. Carpenter	Wm. M. Mackay, *Secy.*

1905

President—Wm. Kent
1st Vice-President—R. P. Bolton
2nd Vice-President—C. B. J. Snyder
Treasurer—Ulysses G. Scollay
Secretary—Wm. M. Mackay

Board of Governors

Chairman, Wm. Kent

R. P. Bolton	James Mackay
C. B. J. Snyder	B. F. Stangland
B. H. Carpenter	J. C. F. Trachsel
A. B. Franklin	Wm. M. Mackay, *Secy.*

1906

President—John Gormly
1st Vice-President—C. B. J. Snyder
2nd Vice-President—T. J. Waters
Treasurer—Ulysses G. Scollay
Secretary—Wm. M. Mackay

Board of Governors

Chairman, John Gormly

C. B. J. Snyder, *Vice-Chm.*	James Mackay
R. C. Carpenter	B. F. Stangland
Frank K. Chew	T. J. Waters
A. B. Franklin	Wm. M. Mackay, *Secy.*

1907

President—C. B. J. Snyder
1st Vice-President—James Mackay
2nd Vice-President—Wm. G. Snow
Treasurer—Ulysses G. Scollay
Secretary—Wm. M. Mackay

Board of Governors

Chairman, C. B. J. Snyder

James Mackay, *Vice-Chm.*	Frank K. Chew
R. E. Atkinson	A. B. Franklin
R. C. Carpenter	Wm. G. Snow
Edmund F. Capron	Wm. M. Mackay, *Secy.*

1908

President—James Mackay
1st Vice-President—Jas. D. Hoffman
2nd Vice-President—B. F. Stangland
Treasurer—Ulysses G. Scollay
Secretary—Wm. M. Mackay

Board of Governors

Chairman, James Mackay

Jas. D. Hoffman, *Vice-Chm.*	John F. Hale
B. F. Stangland	August Kehm
R. C. Carpenter	C. B. J. Snyder
Frank K. Chew	Wm. M. Mackay, *Secy.*

1909

President—Wm. G. Snow
1st Vice-President—August Kehm
2nd Vice-President—B. S. Harrison
Treasurer—Ulysses G. Scollay
Secretary—Wm. M. Mackay

Board of Governors

Chairman, Wm. G. Snow

August Kehm, *Vice-Chm.*	Samuel R. Lewis
John R. Allen	James Mackay
R. C. Carpenter	B. F. Stangland
B. S. Harrison	Wm. M. Mackay, *Secy.*

1910

President—Jas. D. Hoffman
1st Vice-President—R. P. Bolton
2nd Vice-President—Samuel R. Lewis
Treasurer—Ulysses G. Scollay
Secretary—Wm. M. Mackay

Board of Governors

Chairman, Jas. D. Hoffman

R. P. Bolton, *Vice-Chm.*	John F. Hale
Geo. W. Barr	Samuel R. Lewis
R. C. Carpenter	James Mackay
Judson A. Goodrich	Wm. M. Mackay, *Secy.*

1911

President—R. P. Bolton
1st Vice-President—John R. Allen
2nd Vice-President—A. B. Franklin
Treasurer—Ulysses G. Scollay
Secretary—Wm. W. Macon

Board of Governors

Chairman, R. P. Bolton

John R. Allen, *Vice-Chm.*	A. B. Franklin
John T. Bradley	Jas. D. Hoffman
R. C. Carpenter	August Kehm
James H. Davis	Wm. W. Macon, *Secy.*

1912

President—John R. Allen
1st Vice-President—John F. Hale
2nd Vice-President—Edmund F. Capron
Treasurer—James A. Donnelly
Secretary—Wm. W. Macon

Board of Governors

Chairman, John R. Allen

John F. Hale, *Vice-Chm.*	Dwight D. Kimball
Edmund F. Capron	Samuel R. Lewis
R. P. Bolton	Wm. M. Mackay
Jas. D. Hoffman	Wm. W. Macon, *Secy.*

1913

President—John F. Hale
1st Vice-President—A. B. Franklin
2nd Vice-President—Edmund F. Capron
Treasurer—James A. Donnelly
Secretary—Edwin A. Scott

Board of Governors

Chairman, John F. Hale

A. B. Franklin, *Vice-Chm.*	James A. Donnelly
John R. Allen	Dwight D. Kimball
Edmund F. Capron	Wm. W. Macon
R. P. Bolton	James M. Stannard
Frank T. Chapman	Theodore Weinshank
Ralph Collamore	Edwin A. Scott, *Secy.*

1914

President—Samuel R. Lewis
1st Vice-President—Edmund F. Capron
2nd Vice-President—Dwight D. Kimball
Treasurer—James A. Donnelly
Secretary—J. J. Blackmore

Council

Chairman, Samuel R. Lewis

E. F. Capron, *Vice-Chm.*	John F. Hale
Dwight D. Kimball	Harry M. Hart
John R. Allen	Frank G. McCann
Frank T. Chapman	Wm. W. Macon
Frank I. Cooper	James M. Stannard
James A. Donnelly	J. J. Blackmore, *Secy.*

1915

President—Dwight D. Kimball
1st Vice-President—Harry M. Hart
2nd Vice-President—Frank T. Chapman
Treasurer—Homer Addams
Secretary—J. J. Blackmore

Council

Chairman, Dwight D. Kimball

Harry M. Hart, *Vice-Chm.*	Samuel R. Lewis
Homer Addams	Frank G. McCann
Frank T. Chapman	J. T. J. Mellon
Frank I. Cooper	Henry C. Meyer, Jr.
E. Vernon Hill	Arthur K. Ohmes
Wm. M. Kingsbury	J. J. Blackmore, *Secy.*

1916

President—Harry M. Hart
1st Vice-President—Frank T. Chapman
2nd Vice-President—Arthur K. Ohmes
Treasurer—Homer Addams
Secretary—Casin W. Obert

Council

Chairman, Harry M. Hart

F. T. Chapman, *Vice-Chm.*	Dwight D. Kimball
Homer Addams	Henry C. Meyer, Jr.
Charles R. Bishop	Arthur K. Ohmes
Frank I. Cooper	Fred R. Still
Milton W. Franklin	Walter S. Timmis
E. Vernon Hill	Casin W. Obert, *Secy.*

1917

President—J. Irvine Lyle
1st Vice-President—Arthur K. Ohmes
2nd Vice-President—Fred R. Still
Treasurer—Homer Addams
Secretary—Casin W. Obert

Council

Chairman, J. Irvine Lyle

A. K. Ohmes, *Vice-Chm.*	Harry M. Hart
Homer Addams	E. Vernon Hill
Davis S. Boyden	James M. Stannard
Bert C. Davis	Fred R. Still
Milton W. Franklin	Walter S. Timmis
Charles A. Fuller	Casin W. Obert, *Secy.*

1918

President—Fred R. Still
1st Vice-President—Walter S. Timmis
2nd Vice-President—E. Vernon Hill
Treasurer—Homer Addams
Secretary—Casin W. Obert

Council

Chairman, Fred R. Still

W. S. Timmis, *Vice-Chm.*	J. Irvine Lyle
Homer Addams	E. Vernon Hill
William H. Driscoll	Frank G. Phegley
Howard H. Fielding	Fred. W. Powers
H. P. Gant	Champlain L. Riley
C. W. Kimball	Casin W. Obert, *Secy.*

1919

President—Walter S. Timmis
1st Vice-President—E. Vernon Hill
2nd Vice-Presidents—Milton W. Franklin
Treasurer—Homer Addams
Secretary—Casin W. Obert

Council

Chairman, Walter S. Timmis

E. Vernon Hill, *Vice-Chm.*	Frank G. Phegley
Homer Addams	Fred. W. Powers
Howard H. Fielding	Robt. W. Pryor, Jr.
Milton W. Franklin	Champlain L. Riley
Harry E. Gerrish	Fred R. Still
George B. Nichols	Casin W. Obert, *Secy.*

1920

President.....E. Vernon Hill
1st Vice-President.....Champlain L. Riley
2nd Vice-President.....Jay R. McColl
Treasurer.....Homer Addams
Secretary.....Casin W. Obert

Council

Chairman, E. Vernon Hill

C. L. Riley, *Vice-Chm.*
Homer Addams
Jos. A. Cutler
Wm. H. Driscoll
A. C. Edgar
Alfred Kellogg
Jay R. McColl
George B. Nichols
Robt. W. Pryor, Jr
W. S. Timmis
Perry West
Casin W. Obert, *Secy.*

1921

President.....Champlain L. Riley
1st Vice-President.....Jay R. McColl
2nd Vice-President.....H. P. Gant
Treasurer.....Homer Addams
Secretary.....Casin W. Obert

Council

Chairman, Champlain L. Riley

Jay R. McColl, *Vice-Chm.*
Homer Addams
Jos. A. Cutler
Samuel E. Dibble
Wm. H. Driscoll
H. P. Gant
E. S. Hallett
E. Vernon Hill
Alfred Kellogg
E. E. McNair
Perry West
Casin W. Obert, *Secy.*

1922

President.....Jay R. McColl
1st Vice-President.....H. P. Gant
2nd Vice-President.....Samuel E. Dibble
Treasurer.....Homer Addams
Secretary.....Casin W. Obert

Council

Chairman, Jay R. McColl

H. P. Gant, *Vice-Chm.*
Homer Addams
Jos. A. Cutler
Samuel E. Dibble
Wm. H. Driscoll
E. S. Hallett
L. A. Harding
E. E. McNair
H. J. Meyer
C. L. Riley
Perry West
Casin W. Obert, *Secy.*

1923

President.....H. P. Gant
1st Vice-President.....Homer Addams
2nd Vice-President.....E. E. McNair
Treasurer.....Wm. H. Driscoll
Secretary.....C. W. Obert

Council

Chairman, H. P. Gant

Homer Addams, *Vice-Chm.*
W. H. Carrier
J. A. Cutler
S. E. Dibble
Wm. H. Driscoll
E. S. Hallett
Alfred Kellogg
Thornton Lewis
E. E. McNair
Perry West
Casin W. Obert, *Secy.*

1924

President.....Homer Addams
1st Vice-President.....S. E. Dibble
2nd Vice-President.....William H. Driscoll
Treasurer.....Perry West
Secretary.....F. C. Houghten

Council

Chairman, Homer Addams

S. E. Dibble, *Vice-Chm.*
F. Paul Anderson
W. H. Carrier
J. A. Cutler
William H. Driscoll
H. P. Gant
W. E. Gillham
L. A. Harding
Alfred Kellogg
Thornton Lewis
Perry West
F. C. Houghten, *Secy.*

1925

President.....S. E. Dibble
1st Vice-President.....Wm. H. Driscoll
2nd Vice-President.....F. Paul Anderson
Treasurer.....Perry West
Secretary.....F. C. Houghten

Council

Chairman, S. E. Dibble

Wm. H. Driscoll, *Vice-Chm.*
Homer Addams
F. Paul Anderson
W. H. Carrier
J. A. Cutler
W. E. Gillham
W. T. Jones
Thornton Lewis
J. H. Walker
Perry West
A. C. Willard
F. C. Houghten, *Secy.*

1926

President.....W. H. Driscoll
1st Vice-President.....F. Paul Anderson
2nd Vice-President.....A. C. Willard
Treasurer.....W. E. Gillham
Secretary.....A. V. Hutchinson

Council

Chairman, W. H. Driscoll

F. Paul Anderson, *Vice-Chm.*
W. H. Carrier
J. A. Cutler
S. E. Dibble
W. E. Gillham
C. V. Haynes
W. T. Jones
E. B. Langenberg
Thornton Lewis
J. F. McIntire
A. C. Willard

ATLANTIC CITY LIBRARY
9
1930

1927

President.....F. Paul Anderson
1st Vice-President.....A. C. Willard
2nd Vice-President.....Thornton Lewis
Treasurer.....W. E. Gillham
Secretary.....A. V. Hutchinson

Council

Chairman, F. Paul Anderson

A. C. Willard, *Vice-Chm.*
H. H. Angus
W. H. Carrier
W. H. Driscoll
Roswell Farnham
H. H. Fielding
W. E. Gillham
C. V. Haynes
John Howatt
W. T. Jones
J. J. Kissick
E. B. Langenberg
Thornton Lewis
J. F. McIntire
H. Lee Moore
F. B. Rowley

1928

President.....A. C. Willard
1st Vice-President.....Thornton Lewis
2nd Vice-President.....L. A. Harding
Treasurer.....W. E. Gillham
Secretary.....A. V. Hutchinson

Council

Chairman, A. C. Willard

Thornton Lewis, *Vice-Chm.*
F. Paul Anderson
H. H. Angus
W. H. Carrier
N. W. Downes
Roswell Farnham
C. V. Haynes
John Howatt
W. T. Jones
J. J. Kissick
E. B. Langenberg
J. F. McIntire
H. Lee Moore
F. B. Rowley