HEATING AND VENTILATING GUIDE



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

1926-27

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. 5

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AMERICAN SOCIETY *of* HEATING *and* VENTILATING ENGINEERS

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PREFACE

PROGRESS has been made each year in making a worthwhile contribution toward the dissemination of knowledge about heating and ventilating engineering and the Society's latest effort is THE GUIDE, 1926-27 which is the fifth of these annual editions for engineers, architects, contractors and others who are desirous of having a complete knowledge of the heating and ventilating art.

This fifth edition of THE GUIDE is by far the most comprehensive in the scope, value and usefulness of its data and contains the latest information on modern equipment. To compile this volume of scientific and useful facts the experience of the Society's members the results of its Research Laboratory investigations, and the work of others has been drawn upon and combined with established standard data in a simple, convenient and practical form for reference.

In the growth of THE GUIDE much new data has been added so that on its fifth anniversary it is notable that the Technical Data Section has been substantially increased, with data on entirely new subjects, many drawings have been added and the remaining data revised and brought up-to-the-minute. With new developments in the profession and industry now indicated constant changes in our standards will occur.

Those things which appear for the first time in THE GUIDE, 1926-27 are: a recommended standard set of symbols for drawings, chapters on greenhouse heating, hot blast heating, drying, mechanical draft, use of ozone in ventilation, data on building insulation and brief references to new radiator developments. Extensive revisions and additions have been made to the sections on steam heating, water supply systems, gas heating, oil heating, insulation, the ventilation section and the chapters on heating boilers and human comfort have been entirely rewritten. All of this material has been cross-indexed in a comprehensive manner making this edition of greater usefulness to the user.

In connection with the MANUFACTURERS' CATALOG DATA SECTION a more determined effort has been made to carry out the original idea of having this data as free as possible from all unnecessary selling talk and to present therein only such technical information and instructions concerning each item of apparatus referred to as is of the greatest practical value to both the user and manufacturers, of this apparatus.

While desiring to provide the engineer, architect, contractor, estimator, purchasing agent and draftsman with a complete, convenient and reliable reference data book on modern heating and ventilating practice and equipment, THE GUIDE PUBLICATION COMMITTEE finds that as progress is made in the industry, changes will be necessary and each GUIDE WILL represent the best known engineering practice at the time of publication.

As in the case of the first edition issued in 1922, the second edition published in 1923 and the third designated 1924-25, the fourth in 1925-26 this fifth edition for 1926-27 has extended and simplified much of the technical data with the idea of assisting the engineer, architect and contractor in designing and producing the most effective installations for heating and ventilating various types of buildings.

In every case the various chapters are the product of one or more specialists, nearly all members of the Society and revisions have generally been made by the original authors. Publications of the Society, as well as other sources of information, have been drawn upon for some material and credit has been given in each case.

Great care has been taken to maintain a logical arrangement of data in order that it may be most useful and as in the cases of the four previous editions all Catalog Data have been carefully edited in an effort to eliminate exaggerated statements or claims.

No effort has been spared in compiling data for the improvement of this Fifth Edition of THE GUIDE and the helpful suggestions of its users are gratefully acknowledged, as they have made it possible for this volume to become the standard reference work in our field, thereby performing a needed and valuable service in the advancement of the science.

THE AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS having for its purpose the advancement of the arts and sciences in its fields dedicated this volume to the service of the Industry and hopes that a closer contact between the maker and user of equipment will result in improved service to the country at large.

THE GUIDE for 1926-27 is released with the sincere hope that it will again perform a worthwhile service in advancing the ideals of modern Heating and Ventilating.

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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.

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

1926-27

PART I

HEATING

ALTHOUGH there are many ways of heating buildings the results required are the same no matter what method is used, namely to provide enough heat to compensate for the losses from the structure and maintain an adequate temperature for healthful living or working conditions.

Recognizing that uniform practice in the design of heating systems and some standards in the installation of the necessary piping and equipment are desirable the Society has undertaken the compilation of the most practical information available on the subject for the use of architects, engineers, contractors, students, etc., and for this data has drawn upon the experience of its members, the results of its Research Laboratory investigations, reports of its technical committees, the TRANSACTIONS and other reliable sources.

Heating, like any other service, depends largely upon conditions to be met and the quality of service required. The capacity of a heating system is generally based upon the most severe conditions of outside temperatures and wind velocities to be found in a particular locality. Its design should be governed by the character of the building, the purpose to which it is devoted, the period during which it is to be occupied and the reasonable and most practical methods for operating the heating system should be taken into consideration by the engineer.

Attention is called in this connection to the following:

That the average winter requirements (extending over a period of about 200 days in the colder climates and 150 days in the milder climates) are about 40 per cent, in the colder climates and about 60 per cent in the milder climates, of the requirements generally estimated for the most severe winter conditions, also that these severe conditions exist for just a few days each season. The load factor of a heating system averages from 40 to 60 per cent of the maximum and is considerably below this during a large part of the heating season. Then a heating system designed for maximum conditions will be

operating under a comparatively low load factor for the greater part of the time and may be correspondingly inefficient and uneconomical, unless properly designed to meet these conditions.

In the smaller plants this is hard to overcome without either having a plant too large for economy or too small to heat up in a reasonable time. This is sometimes attempted by having the normal capacity of steam boilers about 60 per cent of that required for maximum conditions which provides for their average operation at about normal capacity and at corresponding overloads for the maximum conditions. In order to make this successful the boiler plant must be adapted to operate successfully on at least 50 per cent overload for short periods. In larger plants the boilers may be divided into two or three units, so that one unit may be operated during mild weather, one or two units during average weather and the entire plant during extreme weather which arrangement is ideal for flexibility and economy.

Another important design problem is to bring the building up to its working temperature. This is a general requirement for buildings that are not heated over night, or which are used periodically and not heated during the time that they are not used. Recent tests have indicated that from 10 to 20 per cent more fuel is required for maintaining normal working temperatures in office buildings throughout the 24 hours than is ordinarily required for maintaining working temperatures throughout the day and allowing the heat to be shut off during the time that the building is not in use. It may be assumed that other classes of buildings would show similar results.

In office buildings, factories and other work places, it is not generally considered so necessary to have the temperature up to normal at the beginning of the working period as it is in schools, churches, theatres and other places of assemblage where the occupants are sitting still, and for this reason the relative capacity of the heating system may be less.

In school buildings and other buildings where the heating of the air for ventilation is a large part of the load, this factor may be greatly reduced by recirculating the air during the heating up period, so that while the entire normal average load on the building may be from two to three times as much for heating the air as for supplying the direct radiation the heating-up load for the air may be reduced to from one-half to one-third of its normal value, so that the total load may not be more than twice the direct radiation load.

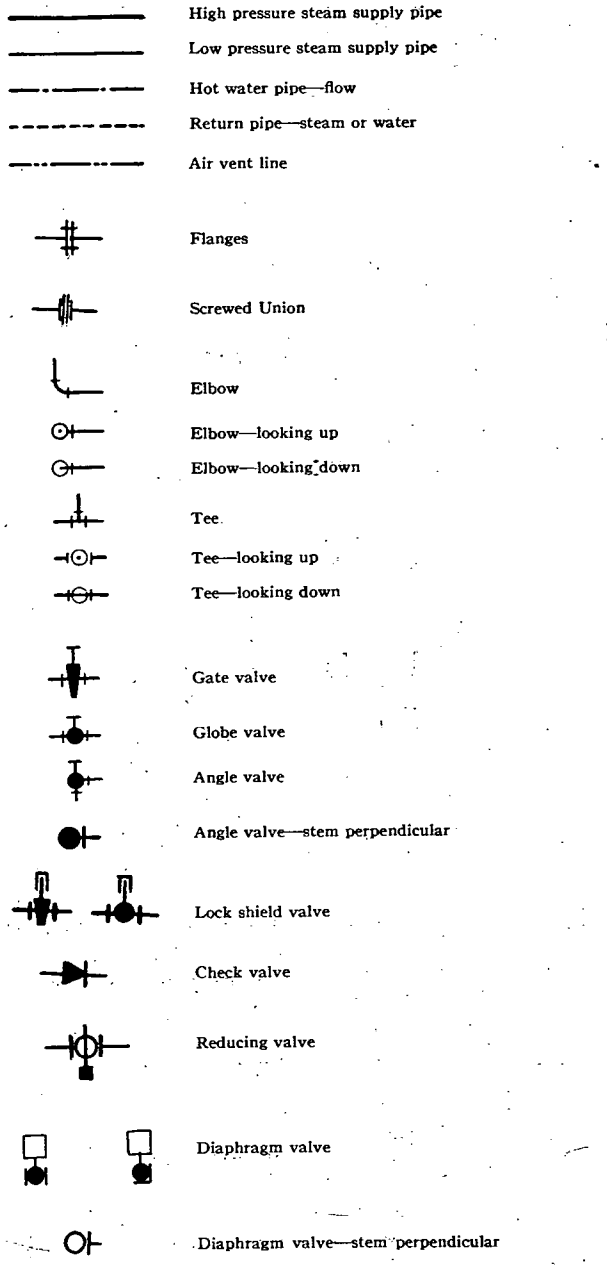
By continuous recirculation for the ventilation, arranged to vary the amount of air taken in from the outside from 100 per cent at an outside temperature of 55 deg. to 25 per cent at an outside temperature of 0 deg. the boiler capacity required for heating the air may be held practically constant at about 25 per cent of that required for 100 per cent of 0 deg. air from the outside.

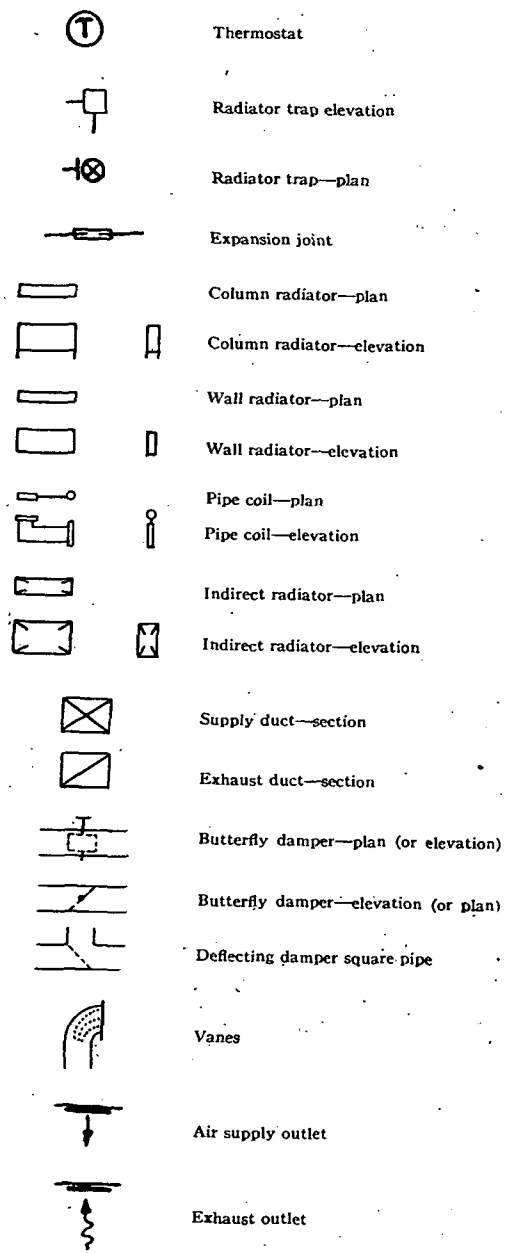
The load factor of the average heating plant is such that the total heat required per month will vary according to the following, when measured in percentage of the total heat required for the season:

OCTOBER	NOVEMBER	DECEMBER	JANUARY	FEBRUARY	MARCH	APRIL
7%	12%	17%	20%	18%	16%	10%

All of these points are covered in the chapters which follow outlining the current practice in determining the heat losses from buildings, selecting the proper size radiators, the correct pipe size, an adequate boiler, explaining the principles of design for a steam, hot water or warm air system, heating with oil or gas, temperature control methods and methods of insulation.

In making plans for heating and ventilating systems the following symbols for drawings are recommended:





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CHAPTER I

HEAT LOSSES FROM BUILDINGS

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.

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.

3. Select or compute the heat transmission coefficients for outside wall and glass, also for floor, or top-floor ceiling, if these are next to unheated space. Include roof if next to heated space.

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

5. Compute the heat transmission losses for each kind of wall, glass, floor, ceiling and roof in the building by multiplying the heat transmisison coefficient in each case by the area of the surface in square feet and the temperature difference between the inside and outside air. (See paragraphs 1 and 2 above.)

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.

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 is the total heat required for warming any building.

INSIDE TEMPERATURE

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.

Data prepared especially for THE GUIDE by Arthur C. Willard, professor of Heating and Ventilation and Head of Department of Mechanical Engineering, University of Illinois, Urbana, Ill.

TABLE 1. INSIDE TEMPERATURES USUALLY SPECIFIED

Type of Building	Deg. Temp.		Deg. Temp.
Warm Air Baths	120	Residences	70
Steam Baths	110	Schools	70
Hospital Operating Room	85	Factories	65
Bath Rooms	85	Stores	65
Paint Shops	80	Gymnasium	55 to 60
Hospitals	72 to 75	Machine Shops	60 to 65
Public Buildings	68 to 72	Foundries, Boiler Shops, etc	50 to 60

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 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 space 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 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.

OUTSIDE TEMPERATURE

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[1] deg. fahr. above the lowest recorded temperature as reported by the U. S. Weather Bureau (Table 2) during the preceding 10 years for the locality in which the heating system is

[1]There seems to be no agreement in this country at present as to the method of arriving at the proper outside temperature to be used in the calculations or design of a heating system. Some offices use the average of the lowest yearly temperatures for the preceding ten years. The *Heating and Piping Contractors' National Association* in their Code arrive at the assumed outside temperature to be used in the design by including a factor for wind movement as recorded for the locality in question. Thus, of two localities with the same minimum recorded outside temperature, the locality having the higher wind velocity would be assigned a lower outside air temperature for the calculation or design of a heating system than the other locality. However, since the effect of wind movement is actually reflected only in the heat transmission coefficients of wall, roof or glass, and in the inleakage (infiltration) of cold air at the cracks around outside windows and doors, its effect should be applied to the transmission and infiltration coefficients and not to the outside air temperature. In this chapter, the practice of correcting transmission and infiltration coefficients for unusual wind movement is followed and the method discussed in detail.

to be installed. The outside temperature assumed and used in the design should always be stated in the heating specifications.

TABLE 2. 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 2. 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

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 average temperature 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 stating the following:

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 average wind velocity in miles per hour for December, January and February, and the direction of the prevailing wind during these same months 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 for the preceding 10 years.

HEAT TRANSMISSION COEFFICIENTS

Definition

The amount of heat expressed in B.t.u. which is transmitted in 1 hr. 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 on 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.

Transmission Coefficients

By means of suitable tests on an actual wall construction, heat transmission coefficients (Table 6) 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 70 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, for the reasons set forth under *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.

The coefficient of heat transmission of various building materials and types of construction as given in Table 6, are for still air and for a wind movement of 15 miles and are generally applicable to heat transmission computations using equation (9). Such heat transmission co-

efficients 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*

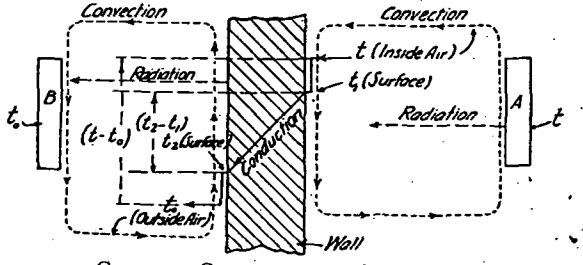


FIG. 1. TEMPERATURE CURVE OR GRADIENT FROM AIR INSIDE TO AND THROUGH WALL TO AIR OUTSIDE, WALL MATERIAL ASSUMED AIR-TIGHT

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.

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.

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 5) 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 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.

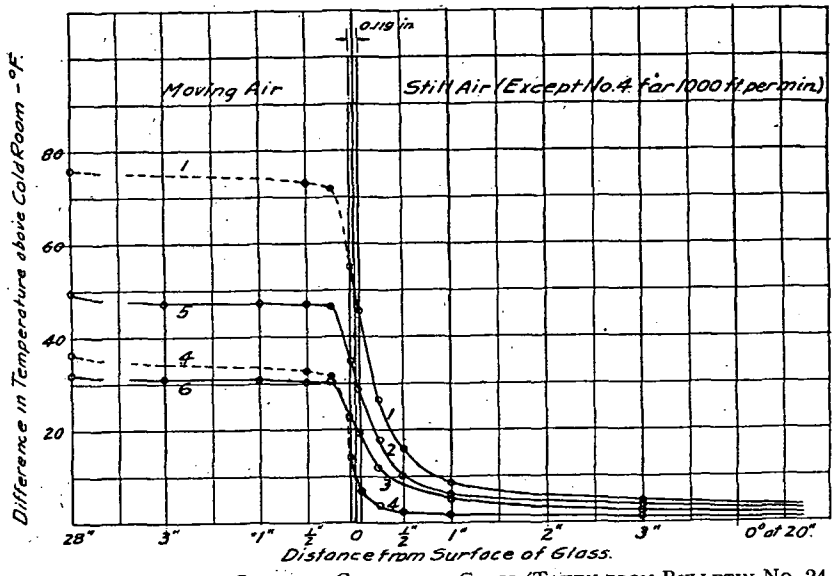


FIG. 2. TEMPERATURE GRADIENT CURVES FOR GLASS (TAKEN FROM BULLETIN NO. 24, ENGRG. EXP. STA., PENNSYLVANIA STATE COLLEGE)

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 a limited number of walls are given in Tables 6-12. 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

$$U = \frac{1}{\frac{1}{K_1} + \frac{1}{K_2} + \frac{x}{C}} \qquad (5)$$

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

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

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 3. Values for C, the conductivity of building materials, are given in Table 4, 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 3. 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 sq. ft. 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.

TABLE 4. CONDUCTIVITY COEFFICIENTS FOR VARIOUS BUILDING MATERIALS[2]

Building Material	Authority: Harding and Willard		Peebles**	Norton	U. S. Bur. Standards
	Coefficient of Conductivity C and Weight per Cu. Ft.				
	Lb. per Cu. Ft.	C	C	C	C
Asbestos (sheet)	48.3	0.29	.....	.....	.....
Asbestos Board (corrugated)	20.4	0.48	.....	.....	.....
Brickwork	132.0	4.00*	.....	.....	.....
Concrete (Stone 1:2:4 Mix)	140.0	8.30	6.30	6.30	.....
Cinder Concrete	.....	.....	5.20	.....	.....
Cork Board	9.7	0.32	0.30	.....	0.350†
Magnesia (board)	13.5	0.51	.....	.....	.....
Wood (Fir, ⅞ in. thick)	33.4	1.00	.....	.....	.....
Yellow Pine Sheathing	.....	.....	1.00	.....	.....
Drop Siding	.....	.....	1.10	.....	.....
Pine Plank	.....	.....	.....	1.25	.....
Maple Flooring	.....	.....	1.20	.....	.....
Mortar (lime)	.....	8.00	.....	.....	.....
Oak Door	.....	.....	1.30	.....	.....
Wood Lath and Plaster	.....	.....	1.10	.....	.....
Metal Lath and Plaster	.....	.....	1.25	.....	.....
Gypsum Partition Tile	.....	.....	1.00	.....	.....
Pyrobar (gypsum)	.....	.....	.....	0.83	.....
Gypsum Reinforced Roof Tile	.....	.....	1.20	.....	.....
Insulex (very light gypsum)	.....	.....	0.50	.....	0.56†
Cabot's Quilt	.....	.....	0.40	.....	0.321†
Insulite	.....	.....	0.33	.....	0.295†
Celotex	.....	.....	0.33	.....	.....
Fibrofelt	.....	.....	.....	.....	0.329
Linofelt	.....	.....	.....	.....	0.300
Lith	.....	.....	.....	.....	0.379
Mineral Wool (medium packed)	.....	.....	.....	.....	0.275
Plaster Board	.....	.....	.....	.....	3.040
Porete	.....	.....	.....	.....	0.941
Sawdust (ordinary)	.....	.....	.....	.....	1.040
Shavings (ordinary)	.....	.....	.....	.....	0.707
Cypress (across grain)	.....	.....	.....	.....	0.667
Keystone Hair	.....	.....	0.29	.....	0.271†
Hair Felt	.....	.....	0.25	.....	0.246†
Roofing Paper and Pitch	.....	.....	.....	1.382	.....
One thickness building paper	.....	.....	4.20***	.....	.....
One course No. 2 tar felt	.....	.....	3.00***	.....	.....
Cornell Wall Board $\frac{3}{16}$ in. thick	.....	.....	2.50***	.....	.....
Glass (act. glass 91.4% total area)	.....	2.06	.....	.....	.....
Double Glass ½ in. air space (glass 69.3% total area)	.....	1.50***	.....	.....	.....
2 in. Tile, ½ in. plast. both surf.	.....	1.00***	.....	.....	.....
4 in. Tile, ½ in. plast. both surf.	.....	0.60***	.....	.....	.....
6 in. Tile, ½ in. plast. both surf.	.....	0.47***	.....	.....	.....
2 in. Tile, plastered as above and roofing covered	.....	0.84	.....	.....	.....

†See TRANSACTIONS, AMERCIAN SOCIETY OF HEATING AND VENTILATING ENGINEERS, Vol. 26, p. 385.
*For damp or wet brickwork take $C = 5$.
**Flat plate method using a test sample 18 in. square and up to 4 in. in thickness.
***For thickness and construction stated, not per 1 in. of thickness.

The values in the tables are in B.t.u. per square foot of wall surface per hour per inch thickness per 1 deg. fahr. difference between the two surfaces, for thoroughly dry materials. For use where air temperature difference on two sides of wall is about 70 deg. and outside air is near zero.

[2]See Chapter IX by Charles 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 the most comprehensive collection of heat transmission data relating to building and insulating material which is now in print.

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,

$$U = \frac{1}{\frac{1}{K_1} + \frac{1}{K_2} + \frac{1}{K_1} + \frac{1}{K_1} + \frac{x}{C}} \qquad (7)$$

or

$$= \frac{1}{\frac{3}{K_1} + \frac{1}{K_2} + \frac{x}{C}} \qquad (8)$$

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 third footnote of Table 4.

TABLE 5. FACTORS TO BE USED IN DETERMINING VALUES OF OUTSIDE SURFACE COEFFICIENTS (K_2) UNDER MOVING AIR CONDITIONS

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.

In each case 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.

Examples of Computations for Walls

The following examples, Fig. 3, will serve to illustrate the method of computing heat transmission coefficients for building walls, including solid walls (simple and compound) and hollow walls. In these examples it has been assumed that a wind movement of about 15 miles per hour exists on the outside of the wall.

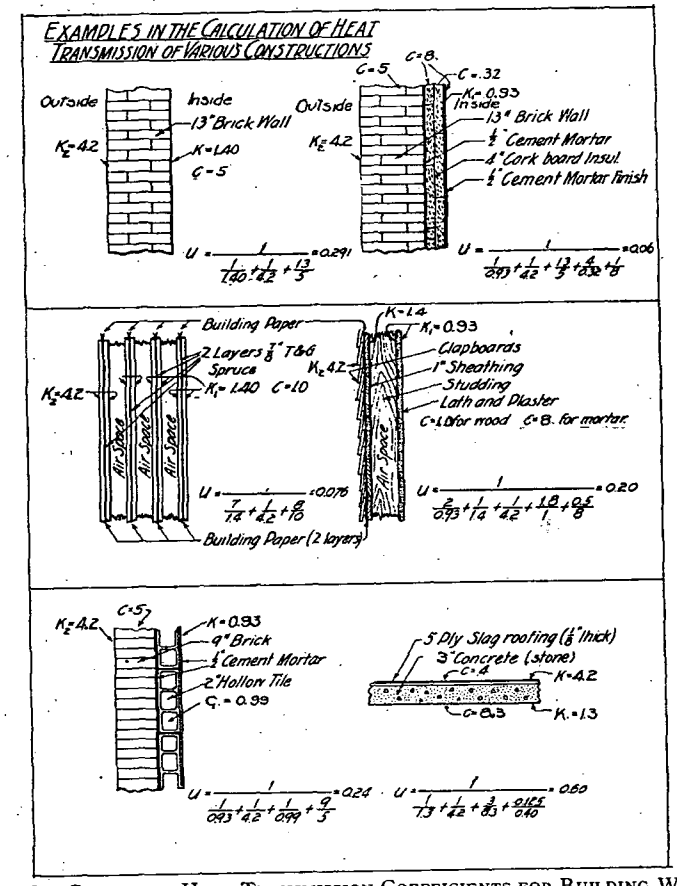


FIG. 3. COMPUTING HEAT TRANSMISSION COEFFICIENTS FOR BUILDING WALLS.

Tables 6 to 12 give transmission constants for a number of types of building construction. These values were determined by computation similar to that shown in Fig. 3, using the values for K and C indicated.

C = conductivity constant for the material. C_{pl}, C_s, C_b etc. conductivity for plaster, stucco, brick etc. C_{t4} in. = conductivity constant for the actual (4 in.) thickness of tile. Considerable variation exists in heat transmission constants used by different authorities, which is due in part to the fact that further research work must be done along this line and also to the fact that the same kind of building material may differ widely depending upon the source and treatment of the raw material from which it is made.

Transmission constants are given for both still air and 15 mile wind. For practical purposes, the constants for any other wind velocity may be obtained with a fair degree of accuracy by interpolating between these values. In a table of this kind it is practically impossible to give values for all types of construction in use and the engineer will frequently be required to determine his own values, as in the examples Fig. 3.

Table 6. Heat Transmission from Various Types of Wall Construction

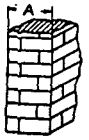
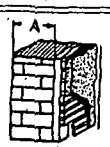
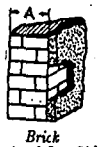
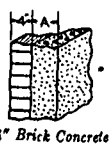
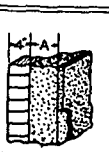
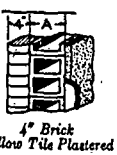
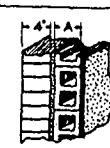
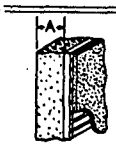
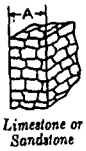
Construction (C = conductivity; K_1 = inside still air; K = air space; K_2 = outside still air; K_3 = outside 15-mi. wind)		Thickness A	B.t.u. transmitted per sq. ft. per hr. per deg. temp. difference between air inside and air outside: Still Air	15-mi. wind
 *Plain Brick Wall*	K_1 = 1.40; K_3 = 4.20; C = 5 0	9″	0.31	0.36
		13″	0.25	0.27
		18″	0.20	0.22
		24″	0.16	0.18
 *Brick Wall and Air Space, Furred and Plastered*	K_1 = 0.93; K_3 = 4.2; C_b = 5; K = 1.4; C_{pl} = 8	9″	0.20	0.22
		13″	0.17	0.19
		18″	0.14	0.16
		24″	0.13	0.13
 *Brick Plastered One Side*	K_1 = 0.93; K_2 = 1.40; K_3 = 4.2; C_{pl} = 8; C_b = 5	9″	0.27	0.30
		13″	0.22	0.25
		18″	0.18	0.20
		24″	0.15	0.16
 *4″ Brick Concrete*	K_1 = 1.30; K_2 = 1.40; K_3 = 4.20; C_b = 5; C_c = 8	4″	0.36	0.43
		8″	0.30	0.36
		12″	0.26	0.30
		16″	0.23	0.26
 *Brick Concrete, Furred, Lathed and Plastered*	K_1 = 0.93; K = 1.3; K_2 = 1.4; K_3 = 4.2; C_b = 5; C_c = 8	4″	0.21	0.23
		8″	0.19	0.21
		12″	0.17	0.19
 *4″ Brick Concrete Plastered*	K_1 = 0.93; K_2 = 1.4; K_3 = 4.2; C_b = 5; C_c & $_{pl}$ = 8	4″	0.32	0.38
		8″	0.27	0.32
		12″	0.24	0.27
 *4″ Brick Hollow Tile*	K_1 = 1.4; K_2 = 1.4; K_3 = 4.2; C_b = 5; $C_t2″$ = 0.99; $C_t4″$ = 0.61; $C_t6″$ = 0.47	2″	0.31	0.36
		4″	0.26	0.30
		6″	0.23	0.26
 *4″ Brick Hollow Tile Plastered*	K_1 = 0.93; K = 1.4; K_3 = 4.2; C_b = 5; C_{pl} = 8; $C_t2″$ = 0.99; $C_t4″$ = 0.61; $C_t6″$ = 0.47	2″	0.27	0.31
		4″	0.23	0.26
		6″	0.21	0.23
 *4″ Brick Hollow Tile Plastered*	K_1 = 0.93; K_2 = 1.4; K_3 = 4.2; C_b = 5; $C_t2″$ = 0.99; $C_t4″$ = 0.61; $C_t6″$ = 0 47	2″	0.278	0.32
		4″	0.238	0.267
		6″	0.212	0.236
 *Concrete*	K_1 = 1.3; K_2 = 1.3; K_3 = 3.9; C = 8.0	2″	0.56	0.78
		3″	0.53	0.72
		4″	0.50	0.66
		6″	0.44	0.56
		8″	0.40	0.49
		12″	0.33	0.40
		16″	0.28	0.33
 *Concrete, Furred, Lathed and Plastered*	K_1 = 0.93; K = 1.4; K_2 = 1.3; K_3 = 3.9; C_c & $_{pl}$ = 8	4″	0.26	0.30
		6″	0.24	0.28
		8″	0.23	0.26
		12″	0.20	0.23
		16″	0.19	0.21
 *Hollow Tile*	K_1 = 1.4; K_2 = 1.4; K_3 = 4.2; $C_{t4″}$ = 0.61; $C_{t6″}$ = 0.47; $C_{t8″}$ = 0.32	4″	0.33	0.39
		6″	0.27	0.32
		8″	0.22	0.25

Table 6. Heat Transmission from Various Types of Wall Construction—Continued

Construction (C = conductivity; K_1 = inside still air; K = air space; K_2 = outside still air; K_3 = outside 15-mi. wind)		Thickness A	B.t.u. transmitted per sq. ft. per hr. per deg. temp. difference between air inside and air outside: Still Air	15-mi. wind
 *Hollow Tile Plastered One Side*	K_1 = 0.93; K_2 = 1.4; K_3 = 4.2; C_{pl} = 8; $C_{t4″}$ = 0.61; $C_{t6″}$ = 0.47; $C_{t8″}$ = 0.32	4″	0.29	0.33
		6″	0.25	0.29
		8″	0.20	0.23
 *Stucco, Hollow Tile Plaster*	K_1 = 0.93; K_2 = 0.93; K_3 = 2.81; C_s & $_{pl}$ = 8; $C_{t4″}$ = 0.61; $C_{t6″}$ = 0.47; $C_{t8″}$ = 0.32	4″	0.26	0.31
		6″	0.23	0.27
		8″	0.19	0.21
 *Stucco, Hollow Tile, Furring, Lath and Plaster*	K_1 = 0.93; K = 1.4; K_2 = 0.93; K_3 = 2.81; C_s & $_{pl}$ = 8; $C_{t4″}$ = 0.61; $C_{t6″}$ = 0:47; $C_{t8″}$ = 0.32	4″	0.18	0.21
		6″	0.17	0.19
		8″	0.15	0.16
 *Limestone or Sandstone*		6″		0.90
		8″		0.80
		10″		0.70
		12″		0.65
		16″		0.55
		20″		0.47
		24″		0.39
 *Limestone Plastered One Side*		4″		0.94
		6″		0.83
		8″		0.70
		10″		0.65
		12″		0.60
		16″		0.50
		20″		0.41
 *Limestone, Furred, Lathed and Plastered*		4″		0.71
		6″		0.60
		8″		0.53
		10″		0.48
		12″		0.43
		16″		0.36
		20″		0.30
 *Stone*		4″		0.99
		6″		0.85
		8″		0.70
		10″		0.64
		12″		0.56
		16″		0.49
		20″		0.39
 *Stone Plastered*		6″		0.79
		8″		0.65
		10″		0.59
		12″		0.51
		16″		0.45
		20″		0.33
 *Stone, Furred, Lathed and Plastered*		6″		0.56
		8″		0.46
		10″		0.42
		12″		0.39
		16″		0.32
		20″		0.25
 *Wood Wall or Floor; Lath & Plaster; Clapboards Sheathing*		⅞″		0.547
		1¾″		0 370
		2⅝″		0.279
 *Windows*		Single		1.126
		Double		0.450
		Triple		0.281
		See also p. 16		

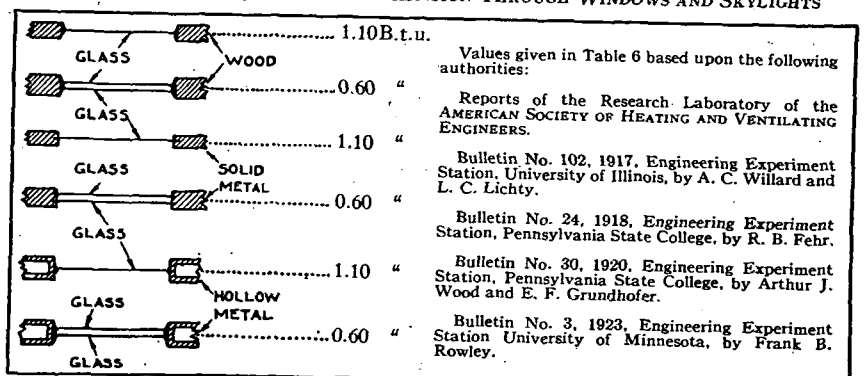
Infiltration Loss—B.t.u. per hour = cu. ft. [leaking in at 70°] × {.075 × .24 × (t − t_o)}

p = perimeter of window in feet. B.t.u. loss per hour per degree diff. = $p \times .60 \times 13 \times 0.147 \times .086 \times 0.24 = 2.4\,p$ for ⅛″ crack — Weather stripped sash = $0.15\,p$

Note: For this method use perimeters of windows on one side of Carpenter's Rule for calculating heat loss of buildings: [room only B.t.u. per hr. = $(G + \frac{1}{4}W + .02NC)(t - t_o)$ W = wall surface; C = cubic contents; G = glass surface; N = number of air changes per hr.

Note.—The volume of air leaking in is measured at a temp. of 70°.

TABLE 6 (Concluded). HEAT TRANSMISSION THROUGH WINDOWS AND SKYLIGHTS



Values given in Table 6 based upon the following authorities:

Reports of the Research Laboratory of the AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS.

Bulletin No. 102, 1917, Engineering Experiment Station, University of Illinois, by A. C. Willard and L. C. Lichty.

Bulletin No. 24, 1918, Engineering Experiment Station, Pennsylvania State College, by R. B. Fehr.

Bulletin No. 30, 1920, Engineering Experiment Station, Pennsylvania State College, by Arthur J. Wood and E. F. Grundhofer.

Bulletin No. 3, 1923, Engineering Experiment Station University of Minnesota, by Frank B. Rowley.

ADDITIONAL COEFFICIENTS FROM ACTUAL TESTS

Based on inside and outside air temperatures with still air on inside and a wind velocity of approximately 15 miles per hr. on outside of walls, glass and roof.

NOTE—For a wind movement other than 15 miles per hr. the value of U must be computed by equations (7) or (8), using the proper value for K_2. See also Tables 3, 4 and 5.

TABLE 7. HEAT TRANSMISSION FOR FLOORS AND CEILINGS

SPECIAL NOTE—Values of U taken from pages 13-16 THE GUIDE 1924-25 appear in Tables 7-12 incl.

ASSUME THE GROUND TEMPERATURE TO BE 50° FAHR.

CONSTRUCTION	B.T.U.
4" CONCRETE, GROUND	.31
4" CONCRETE, CINDER FILL, GROUND	.29
1" TILE, 4" CONCRETE, GROUND	.30
2½" BRICK, 4" CONCRETE, GROUND	.29
1½" WOOD FLOOR, WATERPROOFING, 3" CONCRETE, GROUND	.10
1½" WOOD FLOOR, 3" CONCRETE, CINDER FILL, GROUND, SLEEPERS	.07
1½" WOOD FLOOR, 5" CINDER FILL, GROUND, SLEEPERS	.11
1½" WOOD FLOOR, AIR SPACE, GROUND, SLEEPERS	.13

ASSUME TEMPERATURE OF UNHEATED AIR SPACE TO BE 35° FAHR. WITH AN OUTSIDE TEMPERATURE OF 0°.

CONSTRUCTION	B.T.U.
Unheated Space, Joists, Plaster, Lath	.60
Floor, Joists, Plaster, Lath	.26
Floor, Joists, Metal Ceiling	.36
1" Floor, Joists	.40
Floor, Paper, Floor, Joists	.21
Floor, 4" Reinforced Concrete	.41
4" Reinforced Concrete	1.00
6" Reinforced Concrete	.86
8" Reinforced Concrete	.41
10" Reinforced Concrete	.36

TABLE 8. HEAT TRANSMISSION FOR ROOFS*

CONSTRUCTION	B.t.u. per Deg. Fahr. Difference 15 mi. per hr. wind
1" Wood, 5-Ply Paper, Tar and Gravel	0.30
1" Wood, Felt Roofing	0.36
1½" Wood, 5-Ply Paper, Tar and Gravel	0.26
2" Wood, 5-Ply Paper, Tar and Gravel	0.21
2½" Wood, 5-Ply Paper, Tar and Gravel	0.18
Tin on Wood Strips	1.60
Tin on Sheathing	0.60
Tin on Sheathing, with Paper	0.43
Shingles on Wood Strips	0.87
Shingles on Sheathing	0.43
Shingles, Paper, Sheathing, Strips	0.21
4" Hollow Tile, Paper, Tar and Gravel	0.30
6" Hollow Tile, Paper, Tar and Gravel	0.27
2" Concrete, Paper, Tar and Gravel	0.71
3" Concrete, Paper, Tar and Gravel	0.64
4" Concrete, Paper, Tar and Gravel	0.57
Flat Tile on Wood Strips	1.07
Flat Tile on Sheathing	0.64
Slate on Wood Strips	1.10
Slate on Paper and Sheathing	0.50
Corrugated Iron on Strips	1.50
Corrugated Iron, Sheathing	0.64

*Additional heat transmission constants B.t.u. per square foot per hour per degree temperature difference between inside air and outside air.

TABLE 9. HEAT TRANSMISSION FOR INTERIOR WALLS

CONSTRUCTION	B.t.u. per Deg. Fahr. Difference 15 mi. per hr. wind
Plaster, Lath, Studs, Lath and Plaster	0.34
Studs, Lath and Plaster	0.60
4" Hollow Tile, Plastered 1 Side	0.57
4" Hollow Tile, Plastered Both Sides	0.50
2" Gypsum Block, Plastered 1 Side	0.64
2" Gypsum Block, Plastered Both Sides	0.60

TABLE 10. HEAT TRANSMISSION FOR WOOD DOORS AND WOOD PARTITIONS

	B.t.u. per Deg. Fahr. Difference 15 mi. per hr. wind
¾" to 1" Thick Tongued and Grooved	= 0.65
1" " 1¼" " " " "	= 0.60
1¼" " 1½" " " " "	= 0.50
1½" " 2" " " " "	= 0.42
2" " 2½" " " " "	= 0.35
2½" " 3" " " " "	= 0.30

TABLE 11. HEAT TRANSMISSION FOR WALLS OF VARIOUS CONSTRUCTIONS

THICKNESS OF BOARD IN IN.	TWO BOARDS WITH PAPER BETWEEN	BOARD AND CORRUGATED IRON	BOARD AND SHEET IRON
	B.t.u. Deg. Fahr. Difference 15 mi. per hr. wind	B.t.u. Deg. Fahr. Difference 15 mi. per hr. wind	B.t.u. Deg. Fahr. Difference 15 mi. per hr. wind
½″	0.32	0.45	0.50
1″	0.24	0.36	0.40
1½″	0.19	0.30	0.33
2″	0.16	0.26	0.28
2½″	0.14	0.23	0.25

TABLE 12. HEAT TRANSMISSION FOR WALLS OF CLAPBOARD

CONSTRUCTION	B.t.u. per Deg. Fahr. Difference 15 mi. per hr. wind
Clapboard on Studs	0.62
Clapboard on Studs, Lath and Plaster	0.48
Clapboard, Paper, Studs, Lath and Plaster	0.34
Clapboard, Studs, 1″ Sheathing	0.57
Clapboard, Sheathing, Studs, Lath and Plaster	0.37
Clapboard, Paper, Sheathing, Studs, Lath and Plaster	0.30
Clapboard, Studs, Brick Fill	0.40
Clapboard, Studs, Brick Fill, Papered	0.36
Clapboard, Studs, Brick Fill, Lath and Plaster	0.31
Clapboard, Sheathing, Studs, Lath and Plaster with Sawdust Fill	0.21
Clapboard, Paper, Sheathing, Studs, Lath and Plaster with Sawdust Fill	0.15

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 6 to 12, 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,

$$H_t = SU\,(t - t_o) \tag{9}$$

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_2 for the outside wall surface which is based on the proper wind velocity (Table 5). In case specific data are lacking for any locality, use an average wind velocity of approximately 15 miles per hour. In a similar manner, the heat allowance (Table 15) 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 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

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

$$H_i = 0.24\ Q\ d\ (t - t_0) \qquad (10)$$

where

H_i = B. t.u. per hour required for heating air leaking into building from outside temperature t_0 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_0 = 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 13) 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 brick work 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 recent tests by F. C. Houghten and C. C. Schrader, reported in TRANSACTIONS, A. S. H. AND V. E., Vol. 30, 1924 and Vol. 31, 1925 and others may be conveniently adapted to calculation purposes.

Tables 14 and 15 as well as Figs. 4, 5, and 6 present values from the recent tests by Houghten and Schrader at the Research Laboratory of the AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS at

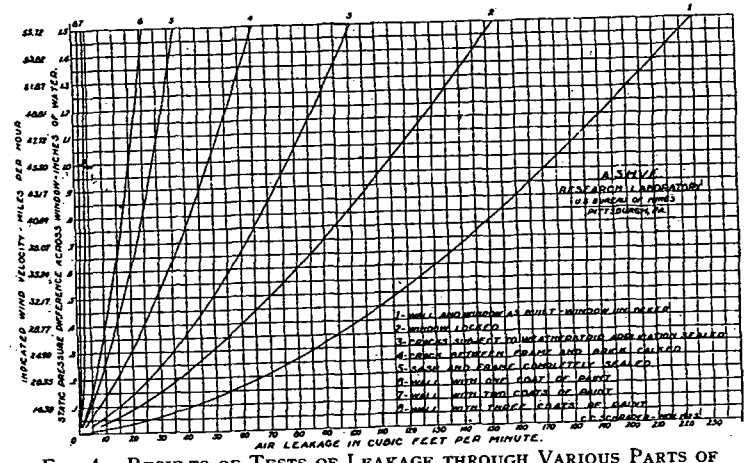


FIG. 4. RESULTS OF TESTS OF LEAKAGE THROUGH VARIOUS PARTS OF WINDOW AND FRAME

Pittsburgh. Table 14 and Fig. 4 based on the report TRANSACTIONS, Vol. 30, 1924, No. 686 while Table 15 and Figs. 5 and 6 are based on data presented in the TRANSACTIONS, Vol. 30, 1924, p. 313.

TABLE 13. 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

Table 14 gives the leakage through a 13 in. brick wall, between the frame and the brick, the leakage for a plain window not weather-stripped

TABLE 14. AIR LEAKAGE IN CUBIC FEET PER HOUR AND B.T.U. NECESSARY TO HEAT SUCH LEAKAGE FROM 0 TO 70 DEG. FAHR. FOR CRACKS INDICATED AND 1/64 IN. CLEARANCE, WINDOW UNLOCKED

	Wind Velocity Miles per Hour	Per Sq. Ft. of 13" Brick Wall; Plastered		Per Ft. of Uncalked Crack Around Frame		Per Ft. of Crack Around the Sash Including Meeting Rail					
						Plain Unstripped Wood Window		Weather Stripped Window			
								Average Results		Best Results	
		Leakage Cu. Ft. per Hour	B.t.u.	Leakage Cu. Ft. per Hour	B.t.u.	Leakage Cu. Ft. per Hour	B.t.u.	Leakage Cu. Ft. per Hour	B.t.u.	Leakage Cu. Ft. per Hour	B.t.u.
PART I Values actually determined by Laboratory tests.	5.0	0.666	0.845	1.76	2.22	49.1	62.5	3.75	4.76	3.27	4.15
	7.5	1.73	2.20	7.95	10.1	78.6	100.0	8.52	10.8	7.20	9.14
	10.0	3.07	3.90	14.1	17.9	106.0	134.0	14.7	18.7	13.1	16.6
	15.0	6.66	8.45	28.3	35.9	155.0	197.0	28.6	36.4	25.6	32.5
	20.0	10.7	13.5	38.8	49.3	201.0	256.0	43.6	55.4	38.6	49.0
	30.0	19.9	25.1	67.1	85.3	291.0	370.0	74.5	94.6	65.5	83.1
	40.0	31.5	40.0	95.0	121.0	386.0	491.0	110.0	139.0	98.2	125.0
	50.0	42.9	54.5	111.0	141.0	498.0	634.0	146.0	186.0	134.0	168.0
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	.532	.676	1.41	1.77	39.3	50.0	3.00	3.80	.....	.....
	7.5	1.38	1.63	6.36	8.08	62.8	80.0	6.82	8.64	.....	.....
	10.0	2.46	3.12	11.3	14.3	84.9	107.0	11.7	14.9	.....	.....
	15.0	5.33	6.76	22.6	28.7	124.0	157.0	22.9	29.1	.....	.....
	20.0	8.54	10.8	31.1	39.4	161.0	204.0	34.9	44.3	.....	.....
	30.0	16.0	20.5	53.6	68.2	233.0	296.0	59.6	75.6	.....	.....
	40.0	25.2	32.0	76.0	96.5	309.0	392.0	87.8	111.0	.....	.....
	50.0	33.3	43.6	88.9	114.0	390.0	507.0	117.0	149.0	.....	.....

TABLE 15. LEAKAGE FOR DOUBLE HUNG UNLOCKED WINDOWS C. F. H. PER FOOT OF CRACK PER MILE WIND VELOCITY AND B.T.U. PER HOUR PER FOOT OF CRACK PER MILE WIND VELOCITY PER 70 DEGREES TEMPERATURE DIFFERENCE

Values Actually Determined by Test		Crack	Plain Window		Weather-Stripped Window							
			1/16"–1/4"		1/16"		1/8"		3/16"		1/4"	
		Clearance	Leakage	B.t.u.	Leakage	B.t.u.	Leakage	B.t.u.	Leakage	B.t.u.	Leakage	B.t.u.
	PART I Best Results	1/32	....	.....	1.32	1.67	1.48	1.87	1.63	2.07	1.79	2.27
		1/16	....	.....	1.56	1.98	1.72	2.18	1.88	2.39	2.05	2.59
		3/32	....	.....	1.67	2.11	1.83	2.32	2.00	2.54	2.17	2.75
		1/8	....	.....	1.71	2.17	1.89	2.39	2.06	2.62	2.24	2.84
		3/16	....	.....	1.74	2.20	1.94	2.45	2.13	2.70	2.33	2.95
		1/4	....	.....	1.75	2.22	1.96	2.48	2.17	2.75	2.38	3.02
	PART II Average Results	1/32	4.3	5.45	1.85	2.30	1.99	2.42	2.21	2.81	2.56	3.25
		1/16	6.6	8.36	2.04	2.58	2.21	2.70	2.46	3.12	2.80	3.55
		3/32	8.9	11.9	2.15	2.72	2.33	2.84	2.58	3.28	2.94	3.72
		1/8	11.2	14.2	2.19	2.78	2.39	2.91	2.66	3.37	3.04	3.84
		3/16	15.7	19.9	2.23	2.82	2.44	2.97	2.74	3.47	3.15	3.99
		1/4	20.2	25.6	2.24	2.84	2.47	3.00	2.79	3.53	3.24	4.10
PART III Values for practical use; Average test values reduced by 20 per cent to allow for building up of pressure in room, etc.		1/32	3.4	4.36	1.48	1.84	1.60	1.93	1.76	2.24	2.04	2.60
		1/16	5.2	6.68	1.63	2.06	1.76	2.16	1.96	2.49	2.24	2.84
		3/32	7.1	9.5	1.72	2.17	1.86	2.27	2.06	2.62	2.35	2.97
		1/8	8.9	11.3	1.75	2.22	1.91	2.32	2.12	2.69	2.43	3.07
		3/16	12.5	15.9	1.78	2.25	1.95	2.37	2.19	2.77	2.52	3.19
		1/4	16.1	20.4	1.79	2.27	1.97	2.40	2.23	2.82	2.59	3.28

and the leakage for the same window fitted with a good weather-strip for various wind velocities.

Table 15 gives the leakage in cubic feet per hour per foot of crack per mile wind velocity for a plain frame window and also for a frame window fitted with weather-stripping. The leakage is given for various cracks around the sash perimeter and also for various clearances (Fig. 5) between the sash and the stop and parting bead.

Tables 14 and 15 are both divided into two parts, the first part containing values based upon the original Research Laboratory test data, and the second part containing the same values reduced by 20 per cent in accordance with the suggestion from the authors. In these tables both the best laboratory results and the average of all laboratory results on weather-stripped windows are given.

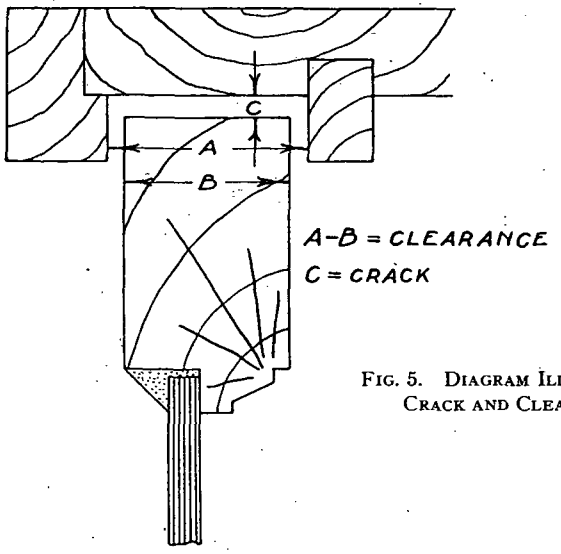


FIG. 5. DIAGRAM ILLUSTRATING CRACK AND CLEARANCE

Table 15 gives the leakage per mile wind velocity. This is based on the assumption that the leakage is proportional to the wind velocity, while this is practically true for a non weather-stripped window it is not so accurate for a weather-stripped window as indicated by the value for different velocities in Table 14. This accounts for the discrepancies in certain parts of the two tables. The two tables are, however, practically in agreement for a thirty mile wind velocity.

According to the authors of the paper: "The values given in the table 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."

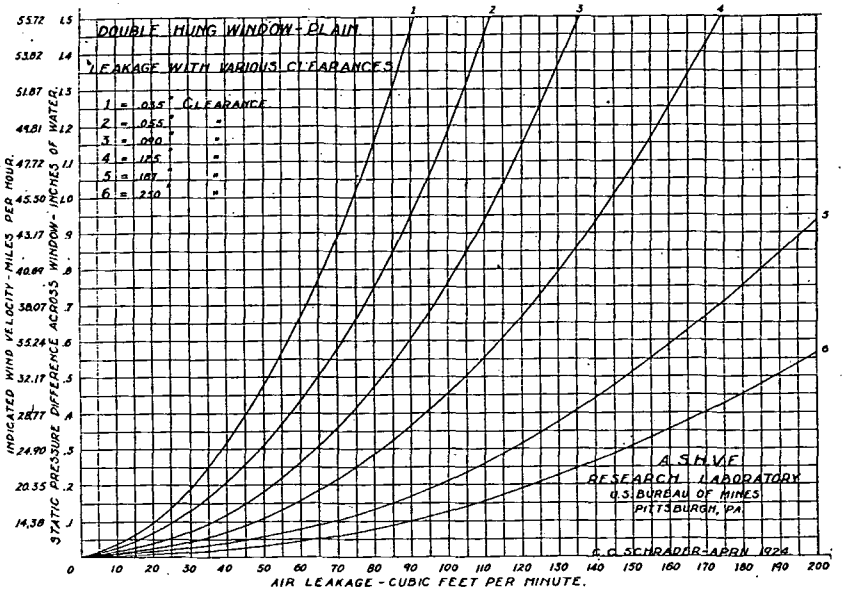


FIG. 6. LEAKAGE THROUGH PLAIN WINDOW WITH VARIOUS CLEARANCES

In their discussion of results as presented in the 1924 report of the TRANSACTIONS, 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 weather-stripped 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 arbi-

trarily to distinguish the two principal air passages which are found in double hung windows, and they will be used frequently throughout the report and should not be confused.

"Four sets of sash were fitted with cracks of $\frac{1}{16}$, $\frac{1}{8}$, $\frac{3}{16}$ and $\frac{1}{4}$ in. Each set was tested with clearances varying from $\frac{1}{32}$ to $\frac{1}{4}$ 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 weather-stripped sashes were tested in the same way.

Fig. 6 gives the results of tests on a plain 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 of from $\frac{1}{16}$ to $\frac{1}{4}$ in. In practice most new sashes are fitted with the crack at least $\frac{1}{16}$ 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.

Calculations for Infiltrations

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 2);

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 14 or 15;

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 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 14, Part II). This value is found in the seventh 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 mi. wind for $\frac{7}{64}$ in. clearance from the 6th column of Table 14.
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 14, Part II).

For a wind velocity other than 15 miles per hour, use the proper velocity for that locality in place of 15.

(1) Plain unstripped window:

$$124 \times 0.075 \times 0.24 = 2.23 \text{ B.t.u. per hour per foot of crack.}$$

(2) Weather-stripped window:

$$22.9 \times 0.075 \times 0.24 = 0.41 \text{ B.t.u. per hour per foot of crack.}$$

Hence, use the values 2.23; and 0.41 for the heat to be supplied in B.t.u. per hour, per foot of crack for an average wind velocity of 15 miles per hour for each of the two kinds of cracks respectively. In case of very good double hung plain windows use $\frac{2.23}{2} = 1.11$.

For special cases, select proper values from Table 14 or 15 and compute the B.t.u. per foot of crack as already shown for the average case, using the proper wind velocity in miles per hour.

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 16. 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 17, 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.

TABLE 17. 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.

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.

Application to Factory Heating[3] (See Fig. 6)

Lowest outside temperature for Philadelphia, Pa. = −6 deg. fahr. (Table 2), hence use (−6 + 10) = + 4 for heat loss computations. Average wind movement (Table 2) 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), furred with 2 in. tile, plastered ½ in.

K_1 = 0.93 plaster in still air, (Table 4).
K_2 = 3 × 1.3 concrete moving air, (Tables 4 and 6).
c_1 = 8.3 for stone concrete, (Table 5).
c_2 = for tile as shown use 0.99 (not per 1 in.), (Table 5).

[3]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 14 for a plain window.

$$U = \frac{1}{\frac{1}{K_1} + \frac{1}{K_2} + \frac{x_1}{c_1} + \frac{x_2}{c_2}} = \frac{1}{\frac{1}{0.93} + \frac{1}{3.9} + \frac{9}{8.3} + \frac{1}{0.99}} =$$

0.292 from equations (6) and (7).

The air temperature at the mean height of inside walls is greater than at breathing line. Mean height of walls is 16 ÷ 2 = 8 ft., which 8 − 5 = 3 ft. above breathing line. Allowing 2 per cent per foot above 5 ft., or 2 × 3 = 6 per cent, makes the mean air temperature 1.06 × 60 = 63.4 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.

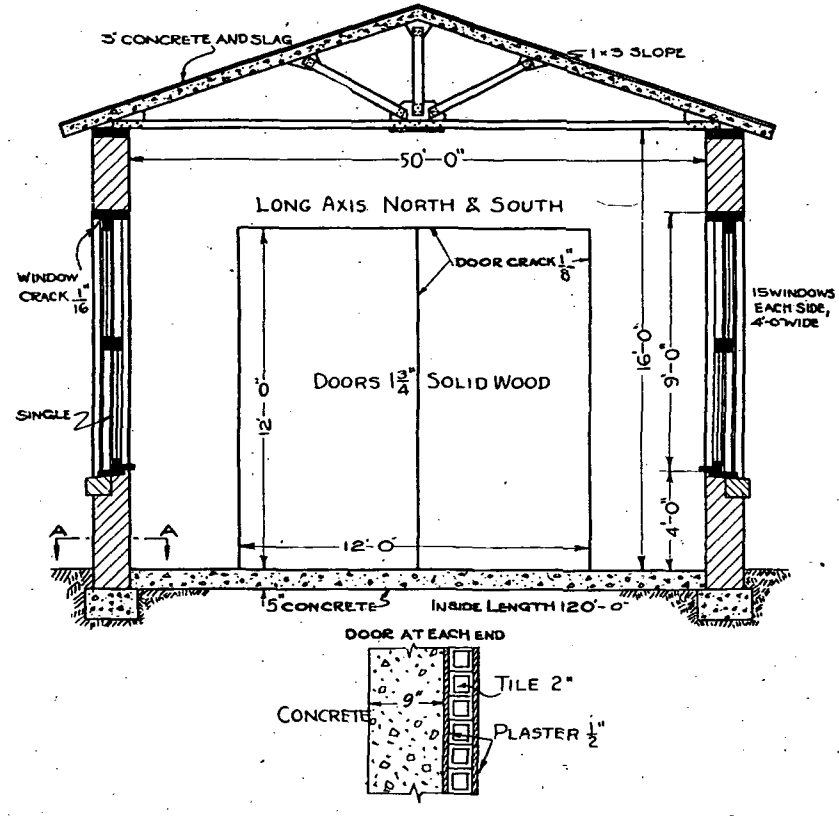


FIG. 7. ELEVATION OF FACTORY BUILDING

Roof: 3 in. concrete (stone), with ⅛ in. tar paper and slag.

$$U = \frac{1}{\frac{1}{K_1} + \frac{1}{K_2} + \frac{x_1}{c_1} + \frac{x_2}{c_2}} = \frac{1}{\frac{1}{1.3} + \frac{1}{4.2} + \frac{3}{8.3} + \frac{0.125}{0.40}} = 0.60$$

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 × 15 = 30 per cent, makes the under roof temperature = 1.30 × 60 = 78 deg. fahr.

Floor: The 5 in. concrete floor is laid on the ground, and hence there is only one surface coefficient $K_1 = 1.3$ (Table 3).

$$U = \frac{1}{\frac{1}{1.30} + \frac{5}{8}} = 0.717$$

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 6). Doors are solid wood 1¾ in. thick and coefficient $U = 0.37$ B.t.u. per sq. ft. per degree per hour (Table 6).

Infiltration: Window crack assumed $\frac{1}{16}$ in. and doors at $\frac{1}{16}$ in. By Table 14 (Part I) for a 10 mile wind velocity the leakage per foot of crack is 85 c.f. hr. for a plain window. The heat equivalent per hour, per degree is

$$85 \times .075 \times 0.24 = 1.53 \text{ B.t.u.}$$

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 × 1.68 = 3.36.

CALCULATION SHEET
Entire Building
(See Fig. 7)

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	0.29	74.0	4,570	1.15	5,250
	N	50	16	656	0.29	59.4	11,300	1.15	13,000
Doors 1¾"	N	12	12	144	0.37	56	2,980	1.15	3,430
Crack ⅛"	N	1 pair doors		60	3.56	56	11,900	½* × 1.15	6,850
									28,530
Concrete and Tile	W	120	16	1380	0.29	59.4	22,900	1.15	26,300
Glass	W	15 × 4	9	540	1.13	59.4	36,200	1.15	41,600
Crack ⅛"	W	Double Hung Windows (15)		450	1.78	59.4	47,500	½* × 1.15	27,300
									95,200
South Wall	Same as N	See above		.....	.....	.....	30,750	½*	24,800
East Wall	Same as W	See above		.....	.....	.....	106,600	½*	82,850
Roof 3" Concrete and Slag	No Ceiling	52.5	120	6300	0.60	74	280,000	None	280,000
Floor 5" Stone Concrete	On Dirt	50	120	6000	0.717	5	21,510	None	21,510

Grand total of heat required for building in B.t.u. per hour at + 4° with 11-mile Southwest wind.. 532,890

*NOTES—(1) This building has no partitions and whatever air enters through the cracks on the windward 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 paragraph 36.

(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 13 for a factory with minimum conditions. Volume = 50 × 120 × 20 (mean height) = 120,000 cu. ft. and heat required per hour is

$$120{,}000 \times \tfrac{1}{2} \times 0.075 \times 0.24 \times 59.4 = 64{,}200 \text{ B.t.u.}$$

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

HEATING BY RADIATION

CALCULATING RADIATION

RADIATION can be classified as direct, semi-direct, and indirect, and is usually made of pipe or cast iron; when it is made of pipe it is termed *pipe coil*, and when made of cast iron it is termed column, wall, semi-indirect, or indirect radiation.

The unit of measure in figuring radiation is the square foot of heating surface, which is the external surface.

The amount of heat a square foot of heating surface (radiation) will give off depends upon the temperature of the heating medium (steam, or hot water), the temperature of the surrounding air, and the velocity at which the air passes over same.

Tables 18 to 24 on succeeding pages indicate the number of B.t.u. a given size column or wall radiator will transmit in 1 hr. with steam as the heating medium and Tables 26 to 30 give similar data with hot water as the heating medium. The ordinary practice in calculating the amount of radiation of various kinds to meet a variety of conditions will be briefly stated.

To determine the amount of direct radiation to heat a room, figure all of the heat losses, add the proper amount for exposure, and refer to Tables 18 to 30 to find the proper size radiator.

If a radiator of more than 20 sections is required, multiply the value, B.t.u. per intermediate section, for the particular radiator, Tables 18–24, by the number of additional sections above 20 and add this amount to the value, *Total B.t.u. per hour*, for the 20 section radiator. This will give the total B.t.u. per hour for the required radiator.

Example.—What is the total B.t.u. per hour for a 30-section 32 in., single column radiator?

Solution.—626 B.t.u. × 10 sections = 6260 B.t.u.
6260 B.t.u. + 12,875 B.t.u. = 19,135 B.t.u. Total per hour for 30-section radiator.

The values, B.t.u. per square feet of intermediate section and B.t.u. per square feet of end surface, are given on the tables to show the relationship between the two. The greater exposure of the end surface on the radiator, obviously will give a greater emission per square feet of surface.

To determine the amount of semi-indirect (sometimes termed direct-indirect), radiation to heat a room, figure all the heat losses, adding the

Prepared especially for THE GUIDE by R. V. Frost, Norristown, Pa.

proper amount for exposure add 40 per cent and refer to Tables 18–24 to find the proper size radiator.

Example.—The heat losses including allowance for exposure for a given size room is 17,200 B.t.u. + 40 per cent or 24,080 B.t.u., requiring a 19-section 45 in. 3-col. semi-indirect radiator.

Pipe coils should be of the header type, with provision made for expansion by a mitre piece. The steam supply should be at the mitre end and all coils should be securely anchored at the return header so as to throw the expansion toward the mitre end. The coils should be made of 1¼ or 1½ in. pipe and not over 60 ft. in length, not including the mitre, which should be at least one-tenth the length of the coil.

SELECTION OF RADIATION

It is usually necessary to select the type and location of radiation to conform to the conditions and space available in the room. In general it is usually most convenient and practical to locate the radiation on the exposed side of the room. The size of the radiator to take care of any particular heat loss can be best selected from the sheets compiled by the Society's Research Laboratory in cooperation with the U. S. Bureau of Mines Experiment Station, which are based on experiments by the late Director John R. Allen, and F. B. Rowley. As the heat emitted per square foot of radiation varies in radiators of different heights, widths and lengths, and also with the steam pressure and the temperature of the room, errors will occur if the same factor is used for all radiators.

Examples for the Use of Tables.—Assume that the heat loss from a room is 15,497 B.t.u. per hr., to heat the room to 70 deg. fahr. Two-column 38-in. radiators have been selected using steam at 1-lb. gage or approximately 215 deg. fahr.

Solution.—In Table 19 for two-column radiators, under 38 in., it will be found that a 17-section radiator will emit 15,960 B.t.u. Therefore a 17-section two-column 38-in. radiator will be required with a rated surface of 68 sq. ft.

If in the same example steam at 5-lb. pressure or approximately 227 deg. fahr. was used and the room was heated to only 60 deg. fahr. requiring 13,300 B.t.u. and three-column 26-in. radiators are selected the radiation would be estimated as follows:

Solution.—In Table 25 following down the first column to 5-lb. gage pressure and then over horizontally to 60 deg. fahr. room temperature the conversion factor 0.864 will be found. The heat loss 13,300 × 0.864 (the equivalent heat loss) = 11,480 B.t.u. In Table 20 for three-column radiators under the heading 26 in. it will be found that a 13-section radiator will supply 11,242 B.t.u. under standard conditions which is the closest to the amount required. Therefore a 13-section three-column 26-in. radiator will be required.

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.
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TABLE 18. HEAT EMITTED BY DIRECT RADIATION—SINGLE-COLUMN RADIATORS

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

LENGTH INCHES	No. OF SECTIONS	38 IN.		32 IN.		26 IN.		23 IN.		20 IN.	
		Rated Surface sq. ft.	Total B.t.u. per hr.	Rated Surface sq. ft.	Total B.t.u. per hr.	Rated Surface sq. ft.	Total B.t.u. per hr.	Rated Surface sq. ft.	Total B.t.u. per hr.	Rated Surface sq. ft.	Total B.t.u. per hr.
	1	3	1125	2.5	952	2	770	1.66	654	1.5	593
5	2	6	1849	5.0	1589	4	1293	3.33	1112	3.0	982
	3	9	2578	7.5	2217	6	1807	5.00	1555	4.5	1377
10	4	12	3307	10.0	2845	8	2321	6.66	1997	6.0	1772
	5	15	4035	12.5	3471	10	2835	8.33	2440	7.5	2168
15	6	18	4765	15.0	4098	12	3348	10.00	2882	9.0	2562
	7	21	5494	17.5	4725	14	3863	11.66	3324	10.5	2957
20	8	24	6223	20 0	5354	16	4377	13.33	3767	12.0	3353
	9	27	6950	22.5	5982	18	4891	15.00	4209	13.5	3748
25	10	30	7680	25.0	6610	20	5404	16.66	4652	15.0	4143
	11	33	8408	27.5	7236	22	5918	18.33	5095	16.5	4538
30	12	36	9137	30.0	7863	24	6432	20.00	5538	18.0	4932
	13	39	9867	32.5	8489	26	6947	21.66	5980	19.5	5327
35	14	42	10594	35.0	9117	28	7459	23.33	6422	21.0	5723
	15	45	11322	37.5	9744	30	7974	25.00	6865	22.5	6118
40	16	48	12053	40.0	10372	32	8489	26.66	7309	24.0	6514
	17	51	12781	42.5	10999	34	9000	28.33	7752	25.5	6908
45	18	54	13511	45.0	11624	36	9515	30.00	8193	27.0	7304
	19	57	14239	47.5	12250	38	10028	31.66	8635	28.5	7698
50	20	60	14964	50.0	12875	40	10544	33.33	9080	30.0	8094
B.t.u. per Intermed. Section			728	....	626	..	514	.....	443	....	395
" " Sq. Ft. "			243	....	250	..	257	.....	266	....	263
" " End Surface			375	....	380	..	385	.....	394	....	395

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TABLE 19. HEAT EMITTED BY DIRECT RADIATION—TWO-COLUMN RADIATORS

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

LENGTH INCHES	NO. OF SECTIONS	45 IN.		38 IN.		32 IN.		26 IN.		23 IN.		20 IN.	
		Rated Surface sq. ft.	Total B.t.u. per hr.	Rated Surface sq. ft.	Total B.t.u. per hr.	Rated Surface sq. ft.	Total B.t.u. per hr.	Rated Surface sq. ft.	Total B.t.u. per hr.	Rated Surface sq. ft.	Total B.t.u. per hr.	Rated Surface sq. ft.	Total B.t.u. per hr.
	1	5	1892	4	1586	3.33	1237	2.66	1100	2.33	967	2	823
5	2	10	2975	8	2475	6.66	2121	5.33	1736	4.66	1520	4	1313
	3	15	4059	12	3373	10.00	2903	8.00	2373	7.00	2093	6	1810
10	4	20	5142	16	4272	13.33	3675	10.66	3010	9.33	2666	8	2304
	5	25	6225	20	5172	16.66	4452	13.33	3652	11.66	3239	10	2798
15	6	30	7308	24	6072	20.00	5220	16.00	4289	14.00	3809	12	3292
	7	35	8390	28	6972	23.33	5992	18.66	4920	16.33	4376	14	3786
20	8	40	9476	32	7869	26.66	6768	21.33	5560	18.66	4943	16	4279
	9	45	10562	36	8766	30.00	7539	24.00	6197	21.00	5510	18	4772
25	10	50	11645	40	9668	33.33	8323	26.66	6832	23.33	6081	20	5264
	11	55	12727	44	10567	36.66	9112	29.33	7471	25.66	6648	22	5753
30	12	60	13810	48	11467	40.00	9888	32.00	8109	28.00	7213	24	6245
	13	65	14892	52	12367	43.33	10662	34.66	8746	30.33	7780	26	6738
35	14	70	15974	56	13266	46.66	11436	37.33	9383	32.66	8346	28	7232
	15	75	17058	60	14164	50.00	12210	40.00	10020	35.00	8897	30	7728
40	16	80	18143	64	15062	53.33	12987	42.66	10662	37.33	9464	32	8221
	17	85	19227	68	15960	56.66	13764	45.33	11299	39.66	10032	34	8714
45	18	90	20311	72	16859	60.00	14538	48.00	11933	42.00	10601	36	9209
	19	95	21394	76	17758	63.33	15310	50.66	12570	44.33	11167	38	9703
50	20	100	22478	80	18656	66.66	16080	53.33	13211	46.66	11736	40	10196
B.t.u. per Intermed. Section			1083	..	900	.....	776	.....	638	.....	565	..	493
" " Sq. Ft. " "			217	..	225	.....	233	.....	240	.....	242	..	246
" " " End Surface			378	..	396	.....	400	.....	413	.....	415	..	411

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TABLE 20. HEAT EMITTED BY DIRECT RADIATION—THREE-COLUMN RADIATORS

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

LENGTH INCHES	NO. OF SECTIONS	45 IN.		38 IN.		32 IN.		26 IN.		22 IN.		18 IN.	
		Rated Surface sq. ft.	Total B.t.u. per hr.	Rated Surface sq. ft.	Total B.t.u. per hr.	Rated Surface sq. ft.	Total B.t.u. per hr.	Rated Surface sq. ft.	Total B.t.u. per hr.	Rated Surface sq. ft.	Total B.t.u. per hr.	Rated Surface sq. ft.	Total B.t.u. per hr.
	1	6	2241	5	1898	4.5	1665	3.75	1372	3	1138	2.25	878
5	2	12	3480	10	2955	9.0	2635	7.50	2195	6	1816	4.50	1430
	3	18	4720	15	4013	13.5	3605	11.25	3017	9	2496	6.75	1961
10	4	24	5959	20	5070	18.0	4674	15.00	3840	12	3174	9.00	2491
	5	30	7197	25	6128	22.5	5544	18.75	4661	15	3854	11.25	3020
15	6	36	8435	30	7185	27.0	6512	22.50	5485	18	4532	13.50	3553
	7	42	9677	35	8243	31.5	7481	26.25	6308	21	5211	15.75	4084
20	8	48	10915	40	9300	36.0	8453	30.00	7128	24	5890	18.00	4615
	9	54	12155	45	10358	40.5	9420	33.75	7952	27	6569	20.25	5146
25	10	60	13392	50	11415	45.0	10391	37.50	8775	30	7248	22.50	5679
	11	66	14632	55	12473	49.5	11360	41.25	9595	33	7927	24.75	6210
30	12	72	15872	60	13530	54.0	12328	45.00	10418	36	8608	27.00	6742
	13	78	17113	65	14587	58.5	13297	48.75	11242	39	9286	29.25	7273
35	14	84	18354	70	15645	63.0	14270	52.50	12065	42	9962	31.50	7803
	15	90	19593	75	16703	67.5	15242	56.25	12889	45	10643	33.75	8333
40	16	96	20832	80	17760	72.0	16207	60.00	13710	48	11323	36.00	8863
	17	102	22068	85	18817	76.5	17174	63.75	14531	51	12000	38.25	9398
45	18	108	23306	90	19872	81.0	18144	67.50	15353	54	12679	40.50	9931
	19	114	24544	95	20936	85.5	19118	71.25	16174	57	13361	42.75	10464
50	20	120	25776	100	21990	90.0	20088	75.00	16995	60	14040	45.00	10989
B.t.u. per Intermed. Section			1239	...	1057	....	969	.....	822	..	679	.....	531
" " Sq. Ft. " "			206	...	211	....	215	.....	219	..	226	.....	236
" " " End Surface			374	...	380	....	370	.....	366	..	380	.....	390

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TABLE 21. HEAT EMITTED BY DIRECT RADIATION—FOUR-COLUMN RADIATORS

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

LENGTH INCHES	NO. OF SECTIONS	45 IN.		38 IN.		32 IN.		26 IN.		22 IN.		18 IN.	
		Rated Surface sq. ft.	Total B.t.u. per hr.	Rated Surface sq. ft.	Total B.t.u. per hr.	Rated Surface sq. ft.	Total B.t.u. per hr.	Rated Surface sq. ft.	Total B.t.u. per hr.	Rated Surface sq. ft.	Total B.t.u. per hr.	Rated Surface sq. ft.	Total B.t.u. per hr.
	1	10	3092	8	2567	6.5	2166	5	1730	4	1430	3	1125
6	2	20	5000	16	4150	13.0	3513	10	2808	8	2320	6	1823
	3	30	6909	24	5730	19.5	4859	15	3887	12	3211	9	2522
12	4	40	8816	32	7315	26.0	6205	20	4964	16	4101	12	3218
	5	50	10725	40	8900	32.5	7550	25	6043	20	4992	15	3917
18	6	60	12636	48	10483	39.0	8896	30	7122	24	5882	18	4615
	7	70	14539	56	12069	45.5	10242	35	8198	28	6773	21	5313
24	8	80	16445	64	13651	52.0	11588	40	9276	32	7664	24	6011
	9	90	18360	72	15235	58.5	12934	45	10355	36	8554	27	6710
30	10	100	20270	80	16816	65.0	14281	50	11435	40	9444	30	7404
	11	110	22176	88	18396	71.5	15627	55	12513	44	10336	33	8103
36	12	120	24084	96	19978	78.0	16973	60	13592	48	11227	36	8802
	13	130	25987	104	21570	84.5	18320	65	14671	52	12118	39	9501
42	14	140	27902	112	23150	91.0	19665	70	15750	56	13009	42	10198
	15	150	29805	120	24732	97.5	21011	75	16827	60	13896	45	10895
48	16	160	31712	128	26330	104.0	22357	80	17904	64	14784	48	11592
	17	170	33626	136	27921	110.5	23702	85	18981	68	15675	51	12291
54	18	180	35537	144	29506	117.0	25049	90	20061	72	16567	54	12987
	19	190	37430	152	31084	123.5	26395	95	21140	76	17459	57	13685
60	20	200	39340	160	32652	130.0	27742	100	22220	80	18352	60	14382
B.t.u. per Intermed. Section			1908	...	1583	.....	1346	...	1078	..	890	..	698
" " Sq. Ft. " "			191	...	198	.....	207	...	216	..	222	..	233
" " " End Surface			309	...	321	.....	333	...	346	..	358	..	375

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TABLE 22. HEAT EMITTED BY DIRECT RADIATION—HOSPITAL RADIATORS—TWO COLUMN

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

LENGTH INCHES	NO. OF SECTIONS	45 IN.		38 IN.		32 IN.		26 IN.		23 IN.		20 IN.	
		Rated Surface sq. ft.	Total B.t.u. per hr.	Rated Surface sq. ft.	Total B.t.u. per hr.	Rated Surface sq. ft.	Total B.t.u. per hr.	Rated Surface sq. ft.	Total B.t.u. per hr.	Rated Surface sq. ft.	Total B.t.u. per hr.	Rated Surface sq. ft.	Total B.t.u. per hr.
	1	5	1966	4	1628	3.33	1391	2.66	1128	2.33	998	2	861
6	2	10	3118	8	2597	6.66	2219	5.33	1812	4.66	1606	4	1391
	3	15	4271	12	3558	10.00	3051	8.00	2498	7.00	2213	6	1921
12	4	20	5424	16	4520	13.33	3878	10.66	3179	9.33	2821	8	2448
	5	25	6575	20	5480	16.66	4710	13.33	3864	11.66	3429	10	2979
18	6	30	7725	24	6439	20.00	5538	16.00	4547	14.00	4036	12	3509
	7	35	8875	28	7400	23.33	6369	18.66	5228	16.33	4644	14	4038
24	8	40	10028	32	8362	26.66	7196	21.33	5913	18.66	5251	16	4568
	9	45	11183	36	9324	30.00	8025	24.00	6600	21.00	5859	18	5099
30	10	50	12335	40	10284	33.33	8856	26.66	7282	23.33	6468	20	5626
	11	55	13487	44	11242	36.66	9684	29.33	7966	25.66	7074	22	6156
36	12	60	14640	48	12206	40.00	10512	32.00	8650	28.00	7683	24	6686
	13	65	15789	52	13166	43.33	11341	34.66	9330	30.33	8290	26	7215
42	14	70	16940	56	14129	46.66	12169	37.33	10016	32.66	8899	28	7744
	15	75	18090	60	15084	50.00	13000	40.00	10696	35.00	9506	30	8274
48	16	80	19248	64	16045	53.33	13829	42.66	11378	37.33	10114	32	8803
	17	85	20400	68	17007	56.66	14658	45.33	12062	39.66	10722	34	9333
54	18	90	21551	72	17971	60.00	15486	48.00	12744	42.00	11327	36	9864
	19	95	22705	76	18932	63.33	16314	50.66	13425	44.33	11935	38	10393
60	20	100	23850	80	19888	66.66	17142	53.33	14111	46.66	12544	40	10920
B.t.u. per Intermed. Section			1152	..	960	.....	829	.....	683	.....	608	..	530
" " Sq. Ft. " "			230	..	240	.....	250	.....	256	.....	261	..	265
" " " End Surface			393	..	407	.....	418	.....	423	.....	428	..	430

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Table 23. Heat Emitted by Direct Radiation—Wall Radiators

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

No. of Sections	29 In.		22 In.		17 In.	
	Rated Surface sq. ft.	Total B.t.u. per hr.	Rated Surface sq. ft.	Total B.t.u. per hr.	Rated Surface sq. ft.	Total B.t.u per hr.
1	9	2853	7	2234	5	1658
2	18	5456	14	4281	10	3208
3	27	8059	21	6327	15	4758
4	36	10663	28	8372	20	6308
5	45	13266	35	10420	25	7860
6	54	15869	42	12466	30	9408
7	63	18472	49	14513	35	10959
8	72	21074	56	16559	40	12508
9	81	23676	63	18604	45	14063
10	90	26280	70	20650	50	15610
11	99	28888	77	22700	55	17160
12	108	31493	84	24746	60	18708
13	117	34094	91	26790	65	20261
14	126	36696	98	28832	70	21812
15	135	39299	105	30881	75	23363
16	144	41904	112	32928	80	24913
17	153	44508	119	34974	85	26461
18	162	47110	126	37019	90	28008
19	171	49715	133	39062	95	29560
20	180	52322	140	41118	100	31110
B.t.u. per Intermediate Section		2603	...	2046	...	1550
" " Sq. Ft. " "		289	...	293	...	310
" " " " End Surface		316	...	319	...	331

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Table 24. Heat Emitted by Direct Radiation—Window Radiators

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

Length Inches	No. of Sections	20 In.		16 In.		13 In.	
		Rated Surface sq. ft.	Total B.t.u. per hr.	Rated Surface sq. ft.	Total B.t.u. per hr.	Rated Surface sq. ft.	Total B.t.u. per hr.
	1	5	1708	3.75	1332	3	1082
6	2	10	2761	7.50	2156	6	1762
	3	15	3816	11.25	2979	9	2441
12	4	20	4872	15.00	3803	12	3119
	5	25	5930	18.75	4626	15	3798
18	6	30	6987	22.50	5450	18	4477
	7	35	8043	26.25	6274	21	5156
24	8	40	9098	30.00	7098	24	5836
	9	45	10152	33.75	7921	27	6516
30	10	50	11210	37.50	8745	30	7194
	11	55	12265	41.25	9570	33	7871
36	12	60	13320	45.00	10395	36	8550
	13	65	14378	48.75	11217	39	9227
42	14	70	15435	52.50	12038	42	9908
	15	75	16490	56.25	12864	45	10589
48	16	80	17544	60.00	13686	48	11266
	17	85	18598	63.75	14510	51	11944
54	18	90	19656	67.50	15336	54	12625
	19	95	20710	71.25	16160	57	13304
60	20	100	21770	75.00	16988	60	13986
B.t.u. per Intermediate Section			1056	.....	.....	..	679
" " Sq. Ft. " "			211	.....	.....	..	226
" " " End Surface			342	.....	.....	..	361

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Table 25. Heat Emitted by Direct Radiation—Conversion Factors

Pressure		Temp. of Steam in deg. fahr.	Temperature of Room in deg. fahr.					
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	2.188	2.053	1.934	1.828	1.733	1.572
19.7	4.75	160	1.898	1.795	1.701	1.621	1.546	1.412
15.3	5.99	170	1.669	1.590	1.517	1.451	1.391	1.285
12.3	7.51	180	1.488	1.425	1.364	1.311	1.261	1.175
8.7	9.33	190	1.339	1.287	1.239	1.195	1.155	1.081
6.5	11.52	200	1.215	1.172	1.135	1.095	1.060	0.999
Lb. Gage								
1	15.7	215	1.064	1.029	1.000	0.971	0.943	0.894
2	16.8	219	1.030	1.000	0.970	0.941	0.915	0.870
3	17.8	222	1.004	0.976	0.947	0.921	0.897	0.851
4	18.9	225	0.982	0.954	0.929	0.902	0.878	0.835
5	19.6	227	0.964	0.936	0.909	0.887	0.864	0.822
6	20.8	230	0.943	0.917	0.892	0.869	0.847	0.806
8	22.8	235	0.907	0.883	0.860	0.839	0.818	0.781
10	24.9	240	0.875	0.853	0.831	0.810	0.791	0.756

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

Table 26. Heat Emission of Direct Cast Iron Radiation for Hot Water—Single Column Radiators

Mean Water Temperature at 170 deg. fahr. — *Room Temperature at 70 deg. fahr.*

Length Inches	Number of Sections	45 In.		38 In.		32 In.		26 In.		23 In.		20 In.	
		Rated Surface Sq. Ft. S	Total B.t.u. per Hr. SR	Rated Surface Sq. Ft. S	Total B.t.u. per Hr. SR	Rated Surface Sq. Ft. S	Total B.t.u. per Hr. SR	Rated Surface Sq. Ft. S	Total B.t.u. per Hr. SR	Rated Surface Sq. Ft. S	Total B.t.u. per Hr. SR	Rated Surface Sq. Ft. S	Total B.t.u. per Hr. SR
	1	....	.....	3	740	2.5	630	2	510	1.66	430	1.5	390
5	2	....	.....	6	1220	5.0	1045	4	850	3.33	725	3.0	650
	3	....	.....	9	1700	7.5	1460	6	1190	5.00	1015	4.5	910
10	4	....	.....	12	2180	10.0	1875	8	1530	6.66	1310	6.0	1170
	5	....	.....	15	2660	12.5	2290	10	1870	8.33	1605	7.5	1430
15	6	....	.....	18	3140	15.0	2705	12	2210	10.00	1900	9.0	1690
	7	....	.....	21	3620	17.5	3120	14	2550	11.66	2190	10.5	1950
20	8	....	.....	24	4100	20.0	3535	16	2890	13.33	2485	12.0	2210
	9	....	.....	27	4580	22.5	3950	18	3230	15.00	2780	13.5	2470
25	10	....	.....	30	5060	25.0	4365	20	3570	16.66	3075	15.0	2730
	11	....	.....	33	5540	27.5	4780	22	3910	18.33	3360	16.5	2990
30	12	....	.....	36	6020	30.0	5195	24	4250	20.00	3650	18.0	3250
	13	...	.....	39	6500	32.5	5610	26	4590	21.66	3945	19.5	3510
35	14	....	.....	42	6980	35.0	6025	28	4930	23.33	4235	21.0	3770
	15	....	.....	45	7460	37.5	6440	30	5270	25.00	4530	22.5	4030
40	16	....	.....	48	7940	40.0	6855	32	5610	26.66	4825	24.0	4290
	17	....	.....	51	8420	42.5	7270	34	5950	28.33	5120	25.5	4550
45	18	....	.....	54	8900	45.0	7685	36	6290	30.00	5415	27.0	4810
	19	....	.....	57	9380	47.5	8100	38	6630	31.66	5710	28.5	5070
50	20	....	.....	60	9860	50.0	8515	40	6970	33.33	6000	30.0	5330
		Two-Column Radiators											
	1	5	1250	4	1050	3.33	860	2.66	725	2.33	640	2	540
5	2	10	1965	8	1640	6.66	1375	5.33	1145	4.66	1020	4	865
	3	15	2680	12	2230	10.00	1890	8.00	1565	7.00	1380	6	1195
10	4	20	3395	16	2820	13.33	2405	10.66	1985	9.33	1760	8	1520
	5	25	4110	20	3420	16.66	2920	13.33	2410	11.66	2135	10	1850
15	6	30	4825	24	4010	20.00	3435	16.00	2830	14.00	2515	12	2170
	7	35	5540	28	4600	23.33	3950	18.66	3250	16.33	2885	14	2500
20	8	40	6255	32	5190	26.66	4465	21.33	3670	18.66	3260	16	2825
	9	45	6970	36	5780	30.00	4980	24.00	4080	21.00	3635	18	3150
25	10	50	7685	40	6375	33.33	5495	26.66	4500	23.33	4015	20	3475
	11	55	8400	44	6970	36.66	6010	29.33	4930	25.66	4380	22	3800
30	12	60	9115	48	7560	40.00	6525	32.00	5350	28.00	4760	24	4120
	13	65	9830	52	8150	43.33	7040	34.66	5770	30.33	5130	26	4440
35	14	70	10545	56	8740	46.66	7555	37.33	6190	32.66	5500	28	4770
	15	75	11260	60	9330	50.00	8070	40.00	6610	35.00	5870	30	5100
40	16	80	11975	64	9930	53.33	8585	42.66	7030	37.33	6250	32	5420
	17	85	12690	68	10520	56.66	9100	45.33	7450	39.66	6620	34	5750
45	18	90	13405	72	11110	60.00	9615	48.00	7870	42.00	7000	36	6080
	19	95	14120	76	11710	63.33	10130	50.66	8290	44.33	7360	38	6410
50	20	100	14835	80	12300	66.66	10645	53.33	8710	46.66	7750	40	6730

TABLE 27. HEAT EMISSION OF DIRECT CAST IRON RADIATION FOR HOT WATER—THREE-COLUMN RADIATORS

Mean Water Temperature at 170 deg. fahr. — *Room Temperature at 70 deg. fahr.*

Length Inches	Number of Sections	45 In.		38 In.		32 In.		26 In.		22 In.		18 In.	
		Rated Surface Sq. Ft. S	Total B.t.u. per Hr. SR	Rated Surface Sq. Ft. S	Total B.t.u. per Hr. SR	Rated Surface Sq. Ft. S	Total B.t.u. per Hr. SR	Rated Surface Sq. Ft. S	Total B.t.u. per Hr. SR	Rated Surface Sq. Ft. S	Total B.t.u. per Hr. SR	Rated Surface Sq. Ft. S	Total B.t.u. per Hr. SR
	1	6	1480	5	1250	4.5	1100	3.75	905	3	750	2.25	600
5	2	12	2295	10	1950	9.0	1740	7.50	1450	6	1200	4.50	945
	3	18	3115	15	2645	13.5	2380	11.25	1990	9	1645	6.75	1295
10	4	24	3930	20	3345	18.0	3020	15.00	2525	12	2095	9.00	1640
	5	30	4750	25	4040	22.5	3660	18.75	3070	15	2540	11.25	1990
15	6	36	5560	30	4740	27.0	4300	22.50	3620	18	2990	13.50	2340
	7	42	6380	35	5430	31.5	4940	26.25	4170	21	3435	15.75	2695
20	8	48	7200	40	6130	36.0	5580	30.00	4710	24	3885	18.00	3045
	9	54	8020	45	6830	40.5	6220	33.75	5250	27	4335	20.25	3395
25	10	60	8830	50	7540	45.0	6860	37.50	5790	30	4780	22.50	3750
	11	66	9650	55	8225	49.5	7500	41.25	6310	33	5230	24.75	4100
30	12	72	10470	60	8930	54.0	8140	45.00	6855	36	5680	27.00	4450
	13	78	11390	65	9625	58.5	8780	48.75	7400	39	6125	29.25	4800
35	14	84	12100	70	10320	63.0	9420	52.50	7950	42	6575	31.50	5150
	15	90	12920	75	11010	67.5	10060	56.25	8500	45	7025	33.75	5500
40	16	96	13750	80	11700	72.0	10700	60.00	9050	48	7475	36.00	5850
	17	102	14570	85	12400	76.5	11340	63.75	9600	51	7920	38.25	6200
45	18	108	15380	90	13100	81.0	11980	67.50	10130	54	8360	40.50	6550
	19	114	16200	95	13800	85.5	12620	71.25	10670	57	8810	42.75	6900
50	20	120	17000	100	14500	90.0	13260	75.00	11200	60	9260	45.00	7250
		FOUR-COLUMN RADIATORS											
	1	10	2040	8	1690	6.5	1430	5	1140	4	945	3	740
6	2	20	3300	16	2740	13.0	2320	10	1850	8	1530	6	1205
	3	30	4560	24	3780	19.5	3205	15	2565	12	2120	9	1665
12	4	40	5810	32	4820	26.0	4090	20	3275	16	2705	12	2120
	5	50	7075	40	5870	32.5	4980	25	3985	20	3300	15	2580
18	6	60	8330	48	6910	39.0	5870	30	4700	24	3880	18	3045
	7	70	9600	56	7960	45.5	6760	35	5410	28	4470	21	3505
24	8	80	10850	64	9000	52.0	7650	40	6120	32	5060	24	3965
	9	90	12100	72	10050	58.5	8530	45	6830	36	5640	27	4425
30	10	100	13350	80	11100	65.0	9420	50	7540	40	6230	30	4885
	11	110	14600	88	12130	71.5	10310	55	8250	44	6820	33	5350
36	12	120	15900	96	13180	78.0	11200	60	8960	48	7410	36	5810
	13	130	17150	104	14230	84.5	12190	65	9675	52	8000	39	6270
42	14	140	18400	112	15280	91.0	12980	70	10390	56	8580	42	6073
	15	150	19650	120	16320	97.5	13870	75	11100	60	9170	45	7190
48	16	160	20900	128	17370	104.0	14760	80	11810	64	9750	48	7650
	17	170	22200	136	18410	110.5	15650	85	12525	68	10340	51	8110
54	18	180	23450	144	19460	117.0	16530	90	13240	72	10930	54	8570
	19	190	24700	152	20500	123.5	17410	95	13950	76	11520	57	9030
60	20	200	25950	160	21550	130.0	18300	100	14700	80	12100	60	9490

TABLE 28. HEAT EMISSION OF DIRECT CAST IRON RADIATION FOR HOT WATER HOSPITAL RADIATORS—TWO-COLUMN

Mean Water Temperature at 170 deg. fahr. — *Room Temperature at 70 deg. fahr.*

Length Inches	Number of Sections	45 In.		38 In.		32 In.		26 In.		23 In.		20 In.	
		Rated Surface Sq. Ft. S	Total B.t.u. per Hr. SR	Rated Surface Sq. Ft. S	Total B.t.u. per Hr. SR	Rated Surface Sq. Ft. S	Total B.t.u. per Hr. SR	Rated Surface Sq. Ft. S	Total B.t.u. per Hr. SR	Rated Surface Sq. Ft. S	Total B.t.u. per Hr. SR	Rated Surface Sq. Ft. S	Total B.t.u. per Hr. SR
	1	5	1300	4	1075	3.33	920	2.66	745	2.33	660	2	570
6	2	10	2060	8	1710	6.66	1470	5.33	1195	4.66	1061	4	920
	3	15	2820	12	2345	10.00	2010	8.00	1645	7.00	1462	6	1270
12	4	20	3580	16	2980	13.33	2560	10.66	2095	9.33	1863	8	1620
	5	25	4340	20	3615	16.66	3105	13.33	2545	11.66	2264	10	1970
18	6	30	5100	24	4250	20.00	3655	16.00	3000	14.00	2665	12	2320
	7	35	5860	28	4885	23.33	4205	18.66	3450	16.33	3066	14	2670
24	8	40	6620	32	5520	26.66	4750	21.33	3900	18.66	3567	16	3020
	9	45	7380	36	6155	30.00	5295	24.00	4350	21.00	3868	18	3370
30	10	50	8140	40	6790	33.33	5840	26.66	4800	23.33	4269	20	3720
	11	55	8900	44	7425	36.66	6390	29.33	5255	25.66	4670	22	4070
36	12	60	9660	48	8060	40.00	6940	32.00	5705	28.00	5071	24	4420
	13	65	10420	52	8695	43.33	7485	34.66	6155	30.33	5472	26	4770
42	14	70	11180	56	9330	46.66	8035	37.33	6605	32.66	5873	28	5120
	15	75	11940	60	9965	50.00	8580	40.00	7055	35.00	6274	30	5470
48	16	80	12700	64	10600	53.33	9125	42.66	7510	37.33	6675	32	5820
	17	85	13460	68	11235	56.66	9670	45.33	7960	39.66	7076	34	6170
54	18	90	14220	72	11870	60.00	10220	48.00	8410	42.00	7477	36	6520
	19	95	14980	76	12505	63.33	10765	50.66	8860	44.33	7878	38	6870
60	20	100	15740	80	13140	66.66	11310	53.33	9315	46.66	8280	40	7220
		Wall		WALL AND WINDOW RADIATORS				*Window*					
		29 In.		22 In.		17 In.		20 In.		16 In.		13 In.	
	1	9	1880	7	1475	5	1095	5	1125	3.75	880	3	715
	2	18	3595	14	2825	10	2115	10	1825	7.50	1425	6	1165
	3	27	5310	21	4175	15	3140	15	2520	11.25	1970	9	1610
	4	36	7025	28	5525	20	4160	20	3220	15.00	2515	12	2060
	5	45	8740	35	6875	25	5185	25	3915	18.75	3060	15	2505
	6	54	10455	42	8225	30	6210	30	4610	22.50	3600	18	2955
	7	63	12170	49	9575	35	7235	35	5310	26.25	4145	21	3405
	8	72	13885	56	10925	40	8260	40	6005	30.00	4690	24	3850
	9	81	15600	63	12275	45	9280	45	6700	33.75	5235	27	4300
	10	90	17315	70	13625	50	10305	50	7400	37.50	5780	30	4745
	11	99	19030	77	14975	55	11325	55	8095	41.25	6320	33	5195
	12	108	20745	84	16325	60	12350	60	8800	45.00	6860	36	5640
	13	117	22460	91	17675	65	13370	65	9495	48.75	7405	39	6090
	14	126	24175	98	19025	70	14395	70	10190	52.50	7950	42	6535
	15	135	25890	105	20375	75	15415	75	10885	56.25	8490	45	6980
	16	144	27605	112	21725	80	16440	80	11580	60.00	9030	48	7435
	17	153	29320	119	23075	85	17460	85	12280	63.75	9575	51	7880
	18	162	31035	126	24425	90	18485	90	12975	67.50	10120	54	8330
	19	171	32750	133	25775	95	19505	95	13670	71.25	10660	57	8780
	20	180	34465	140	27125	100	20540	100	14365	75.00	11200	60	9230

TABLE 29. HEAT EMISSION OF DIRECT PIPE COIL RADIATION FOR STEAM

Steam Temperature at 240 deg. fahr.—Pressure 10 lb. per sq. in.—Room Temperature at 60 deg. fahr.

WALL COILS—Coils Placed Vertical—Pipes Horizontal

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

Size of Coil	1"	1¼"	1½"
Single Row	175	215	245
Two	335	413	462
Four	584	724	816
Six	752	930	1050
Eight	864	1064	1200
Ten	970	1200	1350
Twelve	1075	1330	1500

WALL COILS—Coils Placed Vertical—Pipes Vertical

Emission varies in inverse ratio of the height of the coil. Use 133 B.t.u. per lineal ft. of pipe as an average for 1¼ in. coil, 10 ft. high.

CEILING COILS—Coils Placed Horizontal—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 167 B.t.u. per lineal ft. of pipe for 1 in. coils.
206 " " " " " " " 1¼ in. coils.
231 " " " " " " " 1½ in. coils.

Note.—This Table 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 Tables 17 to 30. The values are therefore approximate only but can be used with assurance that they are more accurate than those obtained by the usual method for calculating pipe coil surface.

TABLE 30. HEAT EMISSION OF DIRECT PIPE COIL RADIATION FOR HOT-WATER

Water Temperature at 180 deg. fahr. Room Temperature at 60 deg. fahr.

WALL COILS—Coils Placed Vertical—Pipes Horizontal

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

Size of Coil	1"	1¼"	1½"
Single Row	105	131	147
Two	198	248	276
Four	352	432	488
Six	456	558	630
Eight	520	640	720
Ten	583	720	810
Twelve	645	800	900

WALL COILS—Coils Placed Vertical—Pipes Vertical

Emission varies in inverse ratio to the height of coil. Use 80 B.t.u. per lineal ft. of pipe as an average for 1¼ in. Coil 10 ft. high.

CEILING COILS—Coils Placed Horizontal—Pipes Horizontal

Emission is equal to that of a single row coil.

Allowance must be made however, if the coil is at the ceiling where the temperature is higher.

In this case use 100 B.t.u. per lineal ft. of pipe for 1 in. coils.
125 " " " " " " " 1¼ in. coils.
138 " " " " " " " 1½ in. coils.

Note.—See note under Ceiling Coils for Steam.

RADIATION FOR ROOM TEMPERATURES

The following table from the Establishment of Standard Methods of Proportioning Direct Radiation, by James A. Donnelly (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 210 deg.) for various room temperatures, when the outside temperature is zero:

TABLE 31. EFFECT OF ROOM TEMPERATURE ON HEAT LOSS AND SIZE OF RADIATOR

Room Temperature	Proportionate Loss in B.t.u.	Difference in Temperature Between Radiator and Room	Proportionate Transmission in B.t.u.	Room Temperature	Proportionate Surface Required Sq. Ft.
35	0.50	175	1.34	35	0.37
40	0.57	170	1.29	40	0.44
45	0.64	165	1.24	45	0.52
50	0.71	160	1.19	50	0.60
55	0.79	155	1.14	55	0.69
60	0.86	150	1.09	60	0.78
65	0.93	145	1.05	65	0.89
70†	1.00†	140†	1.00†	70†	1.00†
75	1.07	135	0.95	75	1.12
80	1.14	130	0.91	80	1.26
85	1.21	125	0.87	85	1.40
90	1.29	120	0.82	90	1.56
95	1.36	115	0.78	95	1.74
100	1.43	110	0.74	100	1.93
105	1.50	105	0.70	105	2.15
110	1.57	100	0.66	110	2.39
115	1.64	95	0.62	115	2.66
120	1.71	90	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 140 deg. difference in temperature (steam 210 deg., building 70 deg.) as standard, or 100 per cent transmission, the second column shows the proportionate transmission when the difference in temperature is as given in the first column.

Assuming that under standard conditions of outside temperature zero, building temperature 70 deg., and radiator temperature 210 deg. (or 140 deg. difference between the radiator and room) the amount of radiation necessary is 100 per cent, the proportionate amounts of radiation given in the second column are those necessary to heat a building to the temperatures given in the first 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.

The preceding table may be used to find the proportionate amount of radiation necessary to heat a room to any desired inside temperature, other than 70 deg., 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., with a temperature of 20 deg. below zero outside, and a steam temperature of 240 deg.

Solution.—The difference in temperature between 20 deg. below outside, and 90 deg. inside, is 110 deg. 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., room 90 deg.) is 150 deg. Opposite this, the proportionate transmission 1.09 is found in the fourth column. Divide 1.57 by 1.09 and the quotient, 1.44 is the proportionate amount of radiation required.

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

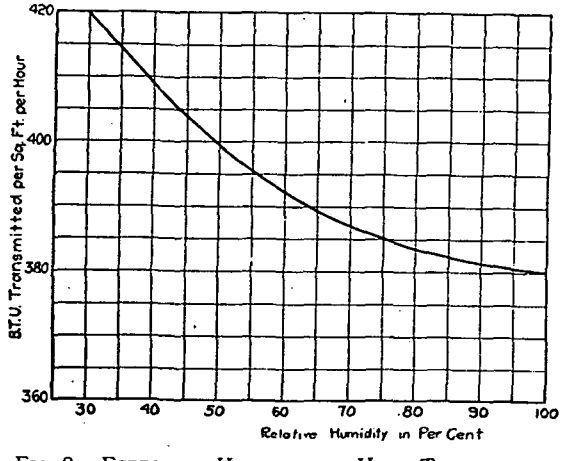


FIG. 8. EFFECT OF HUMIDITY ON HEAT TRANSMISSION

various types of radiation, from which the preceding tables were calculated gives other data from which the following is taken.

Fig. 8 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.

EFFECT OF AIR CIRCULATION

The amount of heat given off by a radiator may also be increased by increasing the velocity of the air over the surface of the radiator. This increase in velocity will increase the amount of heat carried off by convection. No exact data are available on the effects that may be introduced by increasing these velocities over radiator surfaces, but in rooms with moving machinery the heat transmission is increased approximately 10 per cent.

WARMING THE RADIATOR

It is often very important to know the maximum condensation that occurs in a radiator when steam is turned on. Fig. 9 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 occurs 10 min. after steam is turned on, and in that

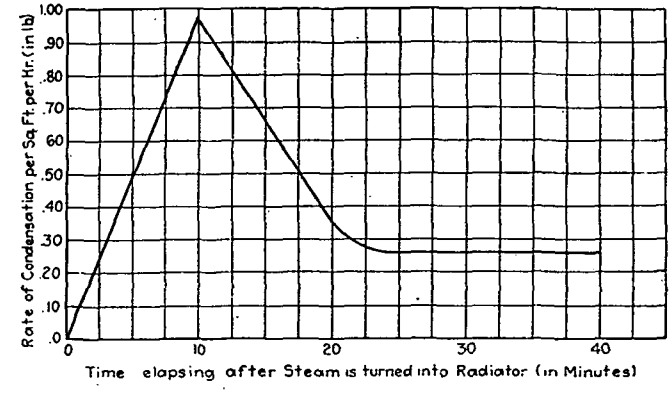


FIG. 9. CHART SHOWS DEMAND UPON BOILER FOR HEATING-UP PLANT

case it amounts to about three and one-half times normal condensation. After the end of 25 min., the radiator had 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 in starting a plant, the demand made upon the boiler may be very much higher than the normal demand.

EFFECT OF PAINTING

The effect of painting was originally determined by experiments made with a cast iron rectangle, and in applying these to radiators of standard type, corrections must be made to allow for the difference between the area of the radiating and convecting surfaces. 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.

TABLE 32. EFFECT OF PAINTING

The result of painting is largely dependent upon the last coat, and is more marked on radiators having a large proportion of radiating surface, as pipe coils or wall radiators, than on radiators having a comparatively small radiating surface in proportion to convecting surface.

PERCENTAGE OF EFFECTIVENESS

Based on Values in Tables as 100 per cent

Cast Iron, bare	100%
Painted with flat black	100%
Painted with aluminum bronze	80%
Painted with gold bronze	81%
Painted with white enamel	101%
Painted with maroon japan	100%
Painted with white zinc paint	101%
Painted with no-lustre green enamel	96%

EFFECT OF ENCLOSING THE RADIATOR

The practice of enclosing radiators has become so general that there is an insistent demand for definite data on the heating effect when so enclosed.

It has been observed that enclosed radiation may give greater heating effect with less condensation than exposed radiators. This result is brought about by a decrease in the radiant effect and an increase in convection effect due to the enclosure.

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

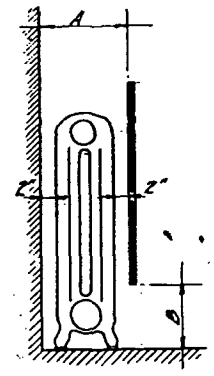
1. Enclosures should be insulated with 1 in. magnesia or asbestos block, lined with bright tin or non-corrosive sheet metal, placed next to the radiator.
2. The surface of the radiator should be painted flat black, maroon japan, white enamel or white zinc. If the radiator is entirely concealed it may 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.

Case 1 is 10 per cent more effective than a direct radiator when properly constructed.
Case 2 is 5 per cent more effective than a direct radiator when properly constructed.
Case 3 is equally as effective as a direct radiator when properly constructed.
Case 4, with *E* equal to one-half *A*,—percentage of reduction is 10 per cent.
Case 4, with *E* equal to *A*,—percentage of reduction is 20 per cent.
Case 4, with *E* equal to 1½*A*,—percentage of reduction is 35 per cent.
Case 5, with *E* equal to *A*,—percentage of reduction is 30 per cent.
Case 6, percentage of reduction is 5 per cent.

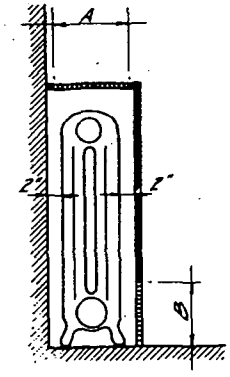
This data applies to the use of cast iron column radiation, with enclosures built-in as part of the architectural treatment of the room and does not apply to other types of enclosed radiators.

EFFECT OF POSITION

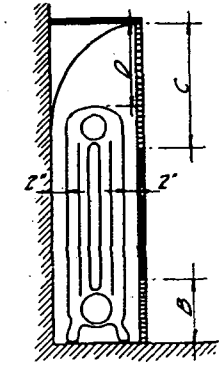
The effect of position on heat transmitted by a radiator is a subject that has been investigated to a very limited extent. Experiments that are now available show the heat loss from a radiator is about the same whether it is placed on the floor, at the ceiling or in the middle of the



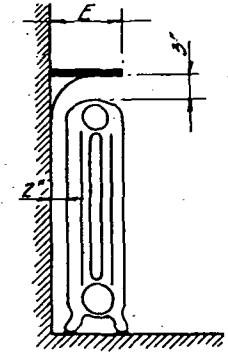
Case 1
FIG. 10



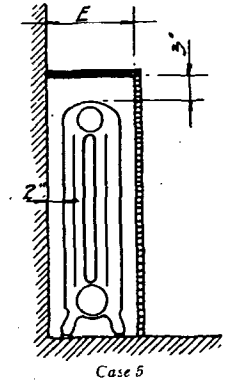
Case 2
FIG. 11



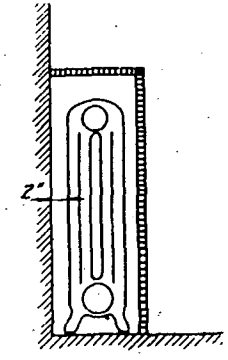
Case 3
FIG. 12



Case 4
FIG. 13



Case 5
FIG. 14



Case 6
FIG. 15

DIFFERENT ARRANGEMENTS OF RADIATORS IN ENCLOSURES

room, air temperatures being the same. It seems to make very little difference whether it is placed near the wall or near the middle of the room, as far as condensation is concerned. There is, however, a considerable difference in the heat of the room and the maintaining of a warm floor. This is particularly the case in rooms in which there is very little circulation of air, due to mechanical means. Many factories that were effectively heated with ceiling radiation when belt drives were used have found it necessary to relocate the radiation at the floor, when direct

motor drives were installed on machines. It has been found under these conditions that high temperatures prevail at the ceiling while low temperatures prevail in the working space. Not only operators have been affected under these conditions but also the output of the individual machines. Best results are obtained when the radiators are placed under the windows and adjacent to doors to the outside. The air heated by the radiators under the windows, rises, mixes with the cold infiltrating air from the windows, circulates across the ceiling, gradually settles to the floor, is drawn up by the radiator and the cycle continues. The advantage of placing radiators adjacent to the door is that the infiltration at this point is compensated for, the infiltrating air being warmed before it enters the heated space.

Placing a radiator close to an outside wall heats the wall immediately behind the radiator, but the infiltrating air through this wall absorbs this heat in part, the rest being used to compensate for the transmission losses through the wall.

SPECIFICATION CLAUSES

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 Tables 18 to 30.

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 sq. in.

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.

CHAPTER III

STEAM HEATING SYSTEMS

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

One-pipe system may be installed as a circuit or as a divided circuit, the steam mains rising close to the basement ceiling above boiler and then grades down from this high point, carrying with it steam and condensate. When the last radiator has been served the main may drop below the water line of boiler, when its size is reduced as the run back to the boiler carries only water, this run is called a "wet return." This return may be run above the water line of boiler, then, it is called a "dry return." In this system the condensate from the radiators returns to the steam main through the feed branches and risers as there is but one connection to the radiators. The air from the system is ejected through air valves properly placed on radiators at the end opposite steam supply, also, on mains properly placed near ends.

Two-pipe systems have two connections to the radiators, one for steam and the other for condensation, air being ejected through air valves properly placed as in the one-pipe system.

Vacuum systems employ a vacuum return pump to produce a vacuum in the system and return the condensation to the boiler.

Vapor or air return systems are two-pipe systems in which all the air and condensation are returned from the radiator through a dry return to a central point, from which point air is ejected from the system and condensate returned to boiler.

This system may or may not use thermostatic traps on the return end of radiators and the pressures used are generally not over a few ounces. Graduated supply valves may or may not be required. There are many variations employing various specialties which are usually patented and determine the name of the patented system. Owing to their specialized nature, none are illustrated here but catalog data on several systems are given in this volume.

Gravity Circulation is the term used to indicate any system where the condensate returns to the boiler by natural flow. Wherever this is the case a certain distance must be allowed between the water line in the boiler and the low point of the steam main and the dry return in order to allow for the pressure drop in the piping system and the proper return of condensate to boiler.

Material for this section compiled by Perry West, consulting engineer, Newark, N. J.; R. V. Frost, consulting engineer, Norristown, Pa., and S. E. Dibble, professor of heating, ventilating and sanitation, Carnegie Institute of Technology, Pittsburgh, Pa.

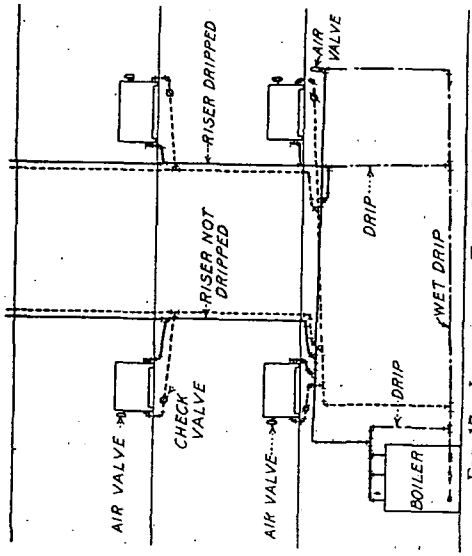


FIG. 17. LAYOUT FOR TWO-PIPE SYSTEM

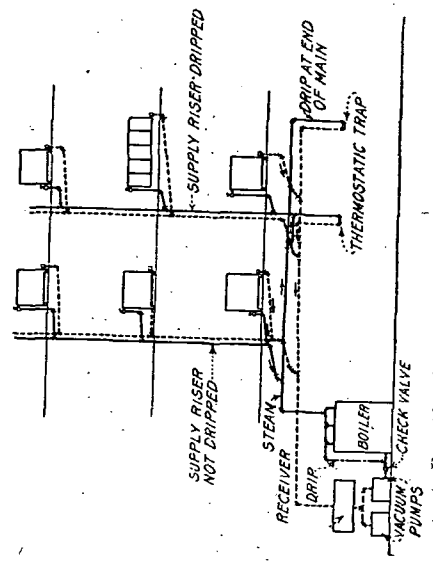


FIG. 19. LAYOUT FOR VACUUM SYSTEM

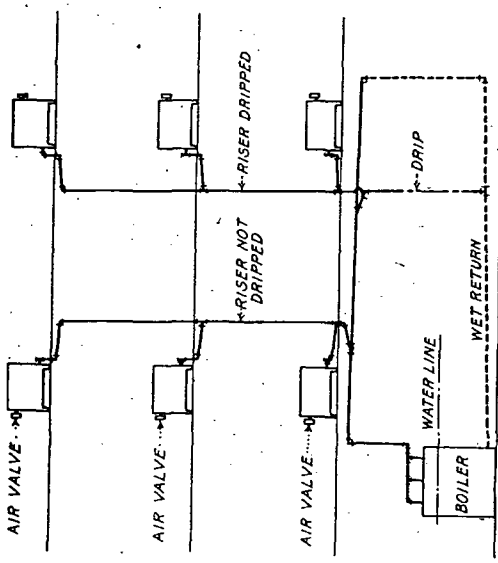


FIG. 16. LAYOUT FOR ONE-PIPE SYSTEM

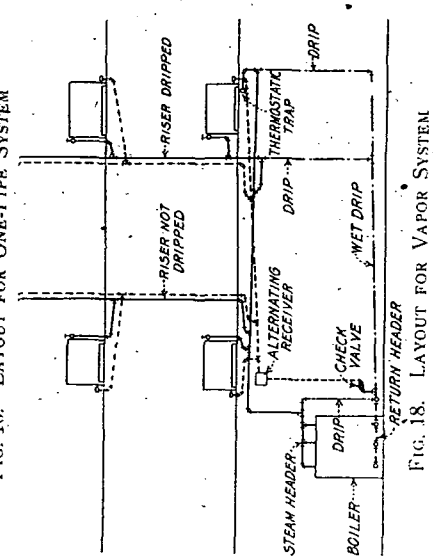


FIG. 18. LAYOUT FOR VAPOR SYSTEM

Mechanical circulation indicates any system where the condensation is returned to the boiler by means of mechanical devises. Pumps for producing mechanical circulation are discussed in Chapter VIII Page 115.

There are two broad divisions that may be very definitely made in the subject of pipe sizes for the heating and ventilating of buildings. The following capacity tables of steam mains and branches, radiator connections, etc., under average conditions should be applied for sizing pipes.

Of the two divisions proposed by James A. Donnelly in Code of Minimum Requirements for the Heating and Ventilation of Buildings, the first covers the distribution of the steam, and the second its use. The conveyance of steam for any considerable distance is a problem by itself, needing separate analysis and altogether different handling from any of the problems concerning the use of the steam after it has arrived at the building to be heated. Steam flow tables should be used for distribution, and tables giving the capacities of steam mains and branches, radiator connections, etc., under standard and average conditions of use should be applied for sizing the pipes within the buildings.

For this reason, data on the subject may be distinguished as:—(1) *transmission mains;* (2) *service piping.*

Transmission mains are those that have to do with the conveying of steam for a distance of considerable extent, through or between buildings and for collecting and returning the water of condensation from the several sections or buildings.

Service piping is that part of the apparatus by which the radiating units are connected to the transmission mains.

The velocities of flow used in the distribution of steam are only limited by the available or allowable drop in pressure, while the velocities within the buildings where the steam is used are limited by the critical velocities or the velocities which will allow of sufficient separation of the condensation so that defective circulation or water hammer will not occur.

STEAM HEATING PIPE SIZES

In using tables for steam heating pipe sizes, it is frequently hard 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 fittings, and valves, etc., but it is generally hard to determine what factors have been allowed for, and what percentage of allowance has been made. In compiling the tables and other data for THE GUIDE, 1926-27 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 radiator.

2. The total pressure drop, which may be allowed, between the source of supply and the end of the return system.

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 friction and other items which cause drop in pressure.

Pressure Drop

There are, theoretically, several factors to be considered, including: the initial pressure, the pressure required at the end of the line, fluctuations in the initial pressure, the distance between the bottom of low point of steam main and dry return and the water line of the boiler (where the condensation is to be returned by gravity), the extra load on the system during heating-up periods, and the critical velocity of the steam (especially in risers and branches where the steam and condensate flow in opposite directions), and in other lines where high velocities are objectionable from the standpoint of noise, or the entrainment of condensate.

With a high initial pressure it is theoretically possible to allow much greater drops in pressure if there is sufficient distance between the low point of steam main and dry return and the water line of the boiler. In attempting any very great drop in pressure, the following practical difficulties present themselves:

1. If the system is designed to secure the same drop in pressure for each unit of radiation (including those nearest, as well as those farthest from the source of supply) the velocity necessary to equalize these drops in the shorter runs will be so high that serious trouble will be encountered from noise and the entrainment of the condensate.

2. If the system is so designed as not to equalize these pressures, the condensate returning from radiators near the source of supply will be at a correspondingly higher temperature than that from radiators farthest from the source of supply, thus causing re-evaporation and pressures in the return system with consequent backing-up from one radiator to another, the holding-up of the return and the filling of the return lines, with too large a percentage of steam instead of condensate.

It has been found, that while it may be theoretically possible to design a system for reatively large pressure drops, it is generally more satisfactory to design heating systems on the basis of a low initial pressure and reasonably low total drops in pressure. The matter of fluctuations in pressure should be taken into consideration wherever the steam is to be supplied directly from the boiler, to the radiators at boiler pressure and the system should be designed to operate properly with the lowest pressure under which the boiler may operate.

With reasonably free venting, the steam supply requirements during the heating-up period may run as high as 300 per cent of the normal maximum load under running conditions (see p. 49, Fig. 9). Allowances should be made for this extra demand, but inasmuch as the steam supply and the demand are somewhat self-regulating, so that if the demand is greater than the supply the pressure will drop and the supply be automatically reduced, the allowance generally made is considerably under 300 per cent. It is more economical to allow for a certain amount of overloading of the system during the heating-up periods and to allow a little more time for heating up than would otherwise be required.

In the matter of initial pressure and return conditions it is undoubtedly true that with a constant initial pressure (such as is produced by a high pressure supply by means of a pressure reducing valve, or from the boiler direct where the pressure is maintained constant), somewhat higher drops in pressure and correspondingly smaller pipe may be successfully used. It is also undoubtedly true that, with a mechanical return line system where a constant vacuum of any desired degree of from 5 to 15 in. of mercury may be maintained, the factor of fluctuations in initial pressure and the difficulties from high velocities and re-evaporation are reduced, so that the pressure drops may also be higher and the pipe sizes smaller.

Unusual Conditions

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

In public buildings, schools, offices, places of assemblage, and such buildings (where the occupants are normally at rest) the building should be heated to its normal temperature at the beginning of each period of use. In some buildings (especially offices, schools and public buildings), the time between heating periods is relatively short; whereas, in others (such as churches, places of assemblage, etc.), these periods are comparatively long. In commercial buildings such as factories, warehouses, etc., where the occupants are normally exercising, it is not necessary for the building to be heated to normal temperature at the beginning of its period of use. These facts should be taken into consideration in the matters of allowances which are to be made in the capacity of the system.

GENERAL DATA ON PIPE SIZE TABLES

The following pipe size tables have been compiled for use in designing steam heating systems, and may be used, by those experienced in the profession, with satisfactory results. The following general principals should be followed:

1. The initial pressure should not exceed 16 oz. gage.

2. It is recommended that the drop in pressure in the mains and riser to the farthest radiator 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.

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. In larger buildings, where boilers are under the constant care of a fireman, a uniform boiler pressure is maintained, and where the water line difference will permit, the total drop in pressure may range from 2 to 8 oz., depending upon the equivalent length of the longest run. The total drop in pressure between the boiler and the farthest radiator, even in a skyscraper, should not exceed 8 oz.

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 radiator, and (*c*) the regularity of the pressure maintained at the boiler or source of steam supply.

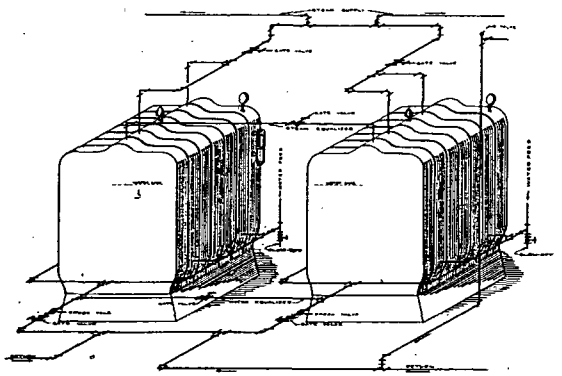


FIG. 20. CONNECTING TWO BOILERS USING CHECK VALVES AND EQUALIZERS IN RETURNS

5. The water line difference or distance between the water line of the boiler and the low point of steam main or dry return main should not be 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 inches.

6. There should be a uniform drop in pressure between the source of steam supply and the farthest radiator on every riser. With a boiler pressure of 16 oz. and a maximum total pressure drop of 8 oz., the steam pressure at the supply valve of the farthest radiator on each riser should be 8 oz. The riser whose farthest radiator is 100 ft. from the main would be sized on a drop of 8 oz. per 100 ft. minus the drop in the main to

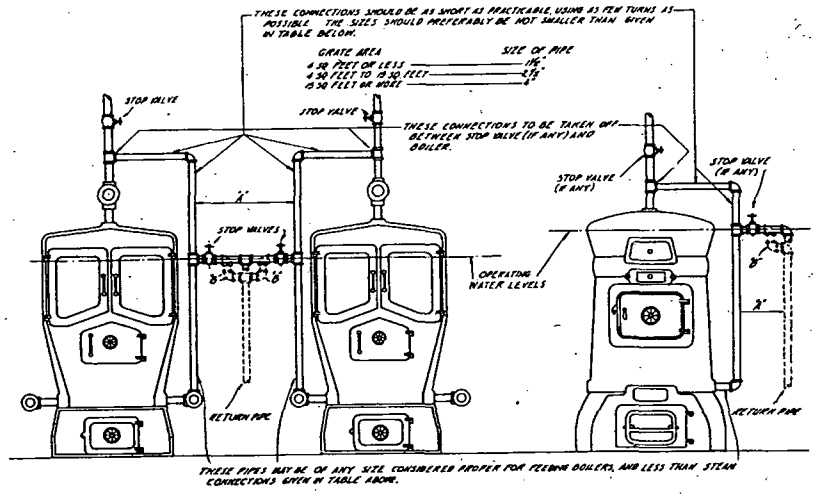


FIG. 21. CONNECTING TWO BOILERS USING THE HARTFORD RETURN LOOP

this riser connection; while one, 200 ft. from the main would be sized on a drop per 100 ft. —one-half of the difference between the drop of 8 oz. and the drop in the main to the riser connection.

The total drop, minus the drop in the main to the point of connection to any riser, divided by the equivalent length of the riser from the main to the farthest radiator in hundreds of feet, gives the drop per 100 ft. in the riser. For a total drop 6 oz., with the farthest radiator on riser No. 4, 200 ft. equivalent from the main and this riser connection 100 ft. from the source of supply, this riser would be sized on a basis of $\frac{6-1}{2}$ or 2½ oz. drop per 100 ft. of riser.

TABLE 33. FLOW OF STEAM IN PIPES

P = Loss in pressure in lb.
d = Inside diameter of pipe in inches
L = Length of pipe in feet
D = Weight of 1 cu. ft. steam
W = Lb. of steam per min.

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

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

Pressure Loss in Oz.	Col. 1 $87.0\sqrt{\frac{P}{100}}$	Inside Dia. Pipe	Col. 2 $\sqrt{\frac{d^5}{1+\frac{3.6}{d}}}$	Steam Pressure By Gage	Col. 3 $\sqrt{D}$	Length Pipe in Feet	Col 4 $\sqrt{\frac{100}{L}}$
1	2.175	1	0.522	0.0	0.193	20	2.240
2	3.076	1¼	1.177	0.3	0.195	40	1.580
3	3.767	1½	1.828	1.3	0.201	60	1.290
4	4.350	2	3.709	2.3	0.207	80	1.120
5	4.863	2½	6.109	5.3	0.223	100	1.000
6	5.328	3	11.183	10.3	0.248	120	0.912
7	5.754	3½	16.705	15.3	0.270	140	0.841
8	6.152	4	23.630	20.3	0.290	160	0.793
10	6.878	4½	32.098	30.3	0.326	180	0.741
12	7.532	5	43.719	40.3	0.358	200	0.710
14	8.138	6	69.718	50.3	0.388	250	0.632
16	8.700	7	105.35	60.3	0.415	300	0.578
20	9.727	8	150.33	75.3	0.452	350	0.538
24	10.655	9	205.37	100.3	0.507	400	0.500
28	11.509	10	271.16	125.3	0.557	450	0.477
32	12.290	12	437.51	150.3	0.603	500	0.447
40	13.756	14	733.90	175.3	0.645	600	0.407
48	15.069	16	925.19	200.3	0.685	700	0.378
80	19.454	.....	.....	.....	.....	800	0.354
160	27.512	.....	.....	.....	.....	900	0.333
320	38.863	.....	.....	.....	.....	1000	0.316
480	47.652	.....	.....	.....	.....	1400	0.267

Column 1 × 2 × 3 × 4 = lb. steam per min. will flow through a straight pipe for a given condition.

Example.—1 oz. drop — 2-in. pipe — 1.3 lb. press. — 100 ft. long — 2.175 × 3.709 × 0.201 × 1 = 1.615 lb. per min., then 1.615 × 60 — 20 per cent = 77.28 lb. per hr.

Preceding table does not allow for entrained water in low-pressure steam, condensation in covered pipe and roughness in commercial pipe, therefore reduce calculated capacities approximately 20 per cent.

In using this method experience indicates that no pipe carries a velocity above the critical value of 20 ft. per second where steam and condensate flow in opposite directions, or above 50 ft. per second elsewhere on account of noise and entrainment difficulties.

7. In order to get uniform distribution of steam throughout the entire system, it is necessary to control the flow by reducing the riser sizes nearer the boiler. The nearer the riser is to the boiler, the greater will be its drop in pressure per 100 ft., since the total drop at the top of all risers should be practically the same.

8. Pipe sizes are figured on a pressure drop basis for steam and water flowing in the same direction or on a critical velocity basis when flowing in the opposite directions.

9. Due to the high rate of condensation in heating up a cold system the critical velocity should be figured at not over 20 ft. per second which will give velocities considerably below the critical velocity once the system is heated.

PIPE SIZES

Table 33 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 pounds of steam per minute which will flow through the pipe may be found, as illustrated in the example accompanying the table.

Table 34 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) 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 does not allow a factor of safety for variation in pipe size, condensation in the pipe or other variables and should not be used without taking these factors into consideration.

Table 35 is the same as Table 34 except that it allows a 20 per cent factor of safety to take care of condensation within the pipe itself, variation in size and roughness in the pipe due to blisters, scaled corrosion and other factors. This table is recommended for general use.

In determining the length of pipe used in any system, the actual length must be increased for the various fittings, and values in determining the equivalent length before applying any of the tables given. Table 36 gives the length in feet to be added to the actual length of pipe for various fittings and values in determining the equivalent length. 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. such capacity may be found from either Table 34 or 35, by multiplying the capacities found in those tables by constants given in Table 37.

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 35 it is found that the capacity of a 100 ft. 4 in. pipe with 1 lb. initial pressure and 2 oz. pressure drop, is 2780 sq. ft. Multiplying this value by 0.841 the constant for a 140 ft. length as given in Table 37 gives 2337 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 35 find, 1926, the capacity of this pipe with a 1 lb. initial pressure. Multiplying this by 1.03 for a 2 lb. initial pressure as given in Table 37 gives 1984 the capacity for the given condition. By using the capacities given in Table 34 rather than Table 35 in examples 1 and 2, the capacities for the given conditions without allowing for a factor of safety of 20 per cent may be obtained.

Table 38 gives the capacities of various sized pipes for parts of systems based upon stated conditions. Column B gives the capacities of various sizes, of supply mains, branches to risers which are dripped, down-feed risers, or any other part of any system where steam and the condensation either from radiation or from the pipe itself flow in the same direction, based upon 1 lb. initial pressure and a drop of 1 oz. per 100 ft. and allowing a 20 per cent factor of safety. These capacities apply particularly to two-pipe steam and two-pipe vapor systems.

Column C gives the capacity of supply mains, branches to risers not dripped, up-feed risers, or any other part of any system where steam and condensate flow in opposite directions, based upon a steam velocity of 16 ft. per second. These capacities apply particularly to a one-pipe system and those parts of any two-pipe system where the condensate from radiators or from the pipe itself are expected to flow in the opposite direction to the steam.

Column D gives the capacity of branches to radiators based upon steam velocities of 12 and 16 ft. per second respectively for such branches with ¼ in. and 1 in. pitch per 10 ft. length.

Table 39 gives the capacity in square feet and pressure drop in ounces for various sized pipe and various steam velocities ranging from 12 to 40 ft. per second.

Tables 40, 41 and 42 give the capacities of return mains, return risers and radiator connections, for vacuum systems. The capacity of supply mains and risers for vacuum systems may be taken directly from Table 35 if the allowable pressure drop is greater than 1 oz. per 100 ft. or from Table 38, Column B, if a pressure drop of only 1 oz. per 100 ft. is to be allowed.

Table 43 gives the pounds of steam which will flow per minute through standard pipe at 4000 ft. velocity, and the resulting pressure drop in pounds per 100 ft. equivalent length. This table is particularly applicable to transmission mains and should not be used without particular consideration in designing distribution systems.

Either capacity of a pipe in any part of a system is limited either by the allowable pressure drop along the pipe, or by the steam velocity through the pipe or both. If condensate, either from radiation supplied or from the pipe itself, is to return counter to the flow of steam the velocity of the steam must not exceed certain critical values. If the velocity exceeds the critical value the system may continue to operate, but will be noisy. If the velocity exceeds a higher maximum value the condensate will cease to return counter to the steam and will be carried along with it clogging the radiator if it has a one-pipe connection, or passing through the radiator if it has a two-pipe connection.

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TABLE 34. PRESSURE LOSSES WITH LOW PRESSURE STEAM

No allowance for condensation in pipe or constriction due to scale or corrosion or other factors

PRESSURE LOSS IN OUNCES PER 100 FT.	PIPE SIZE — ACTUAL 1"	1¼"	1½"	2"	2½"	3"	3½"	NOMINAL 4"	4½"	5"	6"	7"	8"	10"	12"	16"
1	54	122	187	386	635	1163	1737	2407	3338	4545	7250	11,208	15,630	28,194	45,496	96,205
2	75	173	268	546	898	1644	2456	3475	4742	6428	10,230	15,492	22,105	39,876	64,342	136,070
3	94	212	328	668	1100	2013	3078	4256	5781	7872	12,557	18,972	27,071	48,832	78,799	166,630
4	109	245	379	771	1271	2325	3474	4914	6676	9091	14,499	21,909	31,261	56,390	90,992	192,410
5	121	274	424	862	1420	2599	3883	5492	7462	10,162	16,207	24,487	34,941	63,019	101,707	215,170
6	133	300	464	945	1556	2848	4255	6019	8176	11,139	17,758	26,833	38,289	69,068	111,450	235,670
7	144	324	501	1020	1681	3073	4593	6500	8830	12,027	19,179	28,979	41,350	74,590	120,360	254,510
8	153	346	535	1089	1796	3288	4913	6950	9445	12,858	20,505	30,984	44,210	79,730	128,700	272,125
10	172	387	600	1217	2007	3675	5490	7768	10,552	14,371	22,920	34,629	49,413	89,135	143,823	304,148
12	188	424	657	1335	2199	4026	6015	8509	11,559	15,741	25,106	37,934	54,129	97,640	157,550	333,170
14	203	460	710	1443	2377	4349	6497	9191	12,486	17,002	27,127	40,974	58,466	105,466	170,186	359,961
16	217	490	759	1542	2541	4650	6948	9829	13,352	18,181	28,999	43,816	62,522	112,790	181,910	384,830
20	243	547	848	1725	2841	5199	7768	10,988	14,917	20,327	32,422	48,989	69,902	126,090	203,470	430,250
24	265	600	929	1889	3112	5695	8509	12,037	16,352	22,267	35,515	53,661	76,570	138,140	222,880	471,300

TABLE 35. PRESSURE LOSSES WITH LOW PRESSURE STEAM

Twenty per cent allowed for condensation in pipe, variation in size of pipe due to constrictions, scale corrosion and other factors

1	43	97	149	309	508	930	1389	1926	2670	3636	5800	8966	12,504	22,555	36,396	76,964
2	60	138	214	437	718	1315	1965	2780	3793	5142	8200	12,393	17,684	31,900	51,473	108,856
3	76	169	262	534	880	1610	2460	3405	4624	6297	10,045	15,177	21,656	39,065	63,039	133,304
4	87	196	303	617	1017	1860	2779	3931	5341	7272	11,599	17,527	25,008	45,112	72,793	153,928
5	96	219	339	690	1136	2079	3106	4393	5969	8129	12,965	19,589	27,952	50,423	81,366	172,136
6	106	240	371	756	1244	2278	3404	4815	6540	8911	14,206	21,466	30,631	55,254	89,160	188,536
7	115	259	400	816	1345	2460	3676	5200	7064	9621	15,343	23,183	33,080	59,672	96,288	203,608
8	122	276	428	871	1437	2630	3930	5560	7556	10,286	16,404	24,787	35,368	63,800	102,960	217,700
10	137	309	480	973	1605	2940	4392	6214	8441	11,496	18,336	27,703	39,530	71,308	115,038	243,318
12	150	339	525	1068	1759	3221	4812	6807	9247	12,592	20,085	30,347	43,303	78,112	126,040	266,536
14	162	368	568	1154	1902	3479	5197	7352	9989	13,601	21,701	32,779	46,772	84,372	136,149	287,968
16	173	392	607	1233	2033	3720	5558	7863	10,681	14,544	23,199	34,952	50,017	90,232	145,528	307,864
20	194	437	678	1380	2273	4159	6214	8790	11,933	16,261	25,937	39,191	55,921	100,872	162,576	344,200
24	212	480	743	1511	2489	4556	6807	9629	13,081	17,813	28,412	42,928	61,256	110,504	178,304	377,040

Capacities of pipes for various pressure losses in ounces per 100 ft. straight pipe or its equivalent, and 1 lb. initial pressure, steam and condensation flowing in same direction, given in terms of square feet of direct radiation based on ¼ lb. condensation per sq. ft. per hr.
For capacities of pipes other than 100 ft. long, multiply the capacities given by the factor for required length as given in Table 33, Column No. 4.
To determine the pressure loss in a pipe of given size, length and capacity: Multiply pressure loss in ounces per 100 ft. by length of pipe divided by 100.
For capacity with initial pressures other than 1 lb. multiply the capacities given in this table by factor for required pressure in Table 37, Column 2.

TABLE 36. 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.

TABLE 37. CONSTANTS FOR VARIOUS INITIAL PRESSURES AND LENGTHS

STEAM PRESSURE GAGE LBS.	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. 3
Col. 1	Col. 2	Col. 3	Col. 4
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 38. CAPACITY OF PIPE IN SQUARE FEET OF DIRECT RADIATION FOR ONE AND TWO-PIPE STEAM SYSTEMS, WHEN PRESSURE DROP IS NOT OVER 1 OZ. PER 100 FT. OF EQUIVALENT LENGTH OF RUN.

Initial Steam Pressure 1 lb. Gage — *Capacity in Sq. Ft. of Radiation*

A	B	C	D		E	F	Two-Pipe Steam Radiator Valves		One-Pipe Steam Radiator Valves
Commercial Pipe Sizes Inches	Supply Main, Branch to Risers (Dripped) Down Feed Risers, Steam and Condensate Flowing Same Direction	Supply Main, Branch (Not Dripped) to Risers (Not Dripped) Up-Feed Risers, Steam and Condensate Flowing Opposite Direction. 16 Ft. per Sec. Vel.	Branches to Two-Pipe Radiators, Steam and Condensate Flowing in Opposite Direction		Wet Returns	Dry Drips and Return Mains			
			1 in. Pitch per 10 ft. 16 ft. per Sec. Vel.	¼ in. Pitch per 10 ft. 12 ft. per Sec. Vel.		Not Exceeding 400 ft. in Length. Graded no less than 1 in. in 20 ft.	Supply	Gravity Returns	Vacuum Returns
½	...	...	...	...	.....	.....	...	...	100
¾	...	...	...	...	.....	.....	40	40	350
1	43	60	60	40	800	180	63	80	...
1¼	97	90	90	63	1,800	420	90	160	...
1½	149	120	120	90	3,000	900	150	320	...
2	309	210	210	150	6,000	1,500	220	...	...
2½	508	300	300	220	10,000	3,000	...	...	...
3	930	490	...	...	18,000	4,900	...	...	...
3½	1,389	630	...	...	26,000	9,000	...	...	...
4	1,926	800	...	...	37,000	13,000	...	...	...
4½	2,670	...	...	...	Drips for Risers	18,500	...	...	One Pipe Radiator Branches One Pipe Size Larger than Radiator Valves
5	3,636	...	...	...	Drips to Returns	Steam Risers	Drips to Returns		
			Steam Risers		Wet	Dry	Wet	Dry	
6	5,800	...	...	...	¾	¾	2½	1	1¼
			1	1¼	¾	¾	3	1	1¼
7	8,966	...	1	1¼	¾	1	3½	1¼	1½
8	12,504	...	1¼	1½	¾	1	4	1¼	...
10	22,555	...	1½	2	1	1			...
12	36,396	...	2	...					...

Note.—Up-feed two-pipe supply risers may be sized same as supply mains and down-feed risers up to velocities of from 50 ft. to 100 ft. per second corresponding to pipe sizes from 1 in. to 4 in.

TABLE 39. CAPACITY OF PIPE IN SQUARE FEET OF DIRECT RADIATION AND PRESSURE DROPS IN OUNCES PER 100 FT. OF EQUIVALENT LENGTH OF PIPE FOR VARIOUS VELOCITIES OF STEAM

Initial Steam Pressure 1 Lb. Gage.

Size of Pipe	12 Ft. per Sec.		16 Ft. per Sec.		20 Ft. per Sec.		25 Ft. per Sec.		30 Ft. per Sec.		40 Ft. per Sec.	
	Sq. Ft.	P. D.*	Sq. Ft.	P. D.*	Sq. Ft.	P. D.*	Sq. Ft.	P. D.*	Sq. Ft.	P. D.*	Sq. Ft.	P. D.*
¾"	25	1.0	35	2.4	45	3.9	55	6.0	65	8.0	90	16.0
1"	40	0.8	60	2.0	70	2.7	85	3.8	102	5.6	138	10.0
1¼"	63	0.4	90	0.8	115	1.2	145	2.4	172	3.2	235	5.8
1½"	90	0.4	120	0.6	152	0.9	195	1.6	235	2.5	312	4.2
2"	150	0.2	210	0.3	260	0.7	325	1.3	400	1.7	530	3.0
2½"	220	0.18	300	0.3	370	0.5	460	0.7	560	1.2	750	2.7
3"	340	0.17	490	0.25	590	0.4	750	0.7	900	0.9	1210	1.8
3½"	440	0.16	630	0.2	780	0.3	960	0.4	1150	0.6	1550	1.5
4"	650	0.15	800	0.19	1000	0.2	1260	0.3	1500	0.5	2000	1.0

*P. D. = Pressure drop in ounces.

TABLE 40. CAPACITIES OF WET RETURN MAINS IN SQUARE FEET FOR VACUUM SYSTEMS

Size of Pipe	1"	1¼"	1½"	2"	2½"	3"	3½"
*Length 300′	600	1,200	3,000	8,200	15,000	28,500	40,000
" 800′	375	750	1,875	5,200	9,700	17,000	25,000
" 1,000′	.....	700	1,700	4,680	8,700	15,100	23,600
" 1,500′	.....	610	1,420	3,850	7,150	12,300	18,900
" 2,500′	.....	.....	1,125	3,000	5,600	9,425	15,000

*Length equals measured distance from vacuum pump to end of riser.

TABLE 41. CAPACITIES OF RETURN RISERS IN SQUARE FEET FOR VACUUM SYSTEMS

Size of Pipe	¾"	1"	1¼"				
**Length 100′	925	1,850	3,910	.....	.....	.....	.....
" 200′	700	1,400	3,150	.....	.....	.....	.....
" 400′	560	1,120	2,480	.....	.....	.....	.....
" 600′	420	840	1,750	.....	.....	.....	.....
" 1,000′	350	700	1,470	.....	.....	.....	.....
" 2,000′	230	460	1,050	.....	.....	.....	.....

**Length equals measured distance from boiler or pressure reducing valve to end of riser. Capacities as given in Tables 40 and 41, include allowances for elbows, tees, etc.

TABLE 42. RADIATOR CONNECTIONS FOR VACUUM SYSTEMS

Capacity in Sq. Ft. Radiation	Supply			Return		
	Size of Inlet Valve	Vertical Pipe to Inlet Valve	Horizontal Runout to Vertical Inlet Pipe	Size Trap	Stub to Trap	Horizontal Runout to Stub
1 to 60	¾"	¾"	1"	½"	½"	¾"
61 to 100	1"	1"	1¼"	½"	½"	¾"
101 to 200	1¼"	1¼"	1½"	¾"	¾"	¾"
201 to 350	1½"	1½"	2"	¾"	¾"	¾"

Radiators to be water pattern tapped or bushed top and bottom opposite ends.
Steam pattern radiators can be used when tapped or bushed eccentric opposite ends with supply bushing turned up and return bushing turned down.

TABLE 43. FLOW OF STEAM IN POUNDS PER MINUTE THROUGH STANDARD PIPES AND PRESSURE DROP IN POUNDS PER 100 FT.—VELOCITY, 4000 FT. PER MINUTE*

PIPE SIZE INCHES	GAGE PRESSURE IN POUNDS PER SQUARE INCH—STANDARD PIPE																
	1	3	5	10	15	25	35	50	75	100	125	150	175				
½	0.340	0.381	0.420	0.518	0.614	0.805	0.993	1.270	1.727	2.175	2.620	3.072	3.515	Flow			
	2.733	3.100	3.384	4.180	4.955	6.500	8.030	10.25	13.93	17.54	21.22	24.82	28.42	Drop			
¾	0.597	0.668	0.737	0.908	1.077	1.411	1.740	2.225	3.029	3.814	4.593	5.382	6.160	Flow			
	1.610	1.803	1.990	2.452	2.900	3.805	4.700	6.000	8.190	10.29	12.37	14.53	16.66	Drop			
1	0.968	1.083	1.195	1.473	1.746	2.287	2.821	3.608	4.908	6.182	7.448	8.730	9.990	Flow			
	1.061	1.190	1.310	1.516	1.913	2.492	3.090	3.956	5.385	6.775	8.165	9.585	10.99	Drop			
1¼	1.675	1.873	2.068	2.548	3.023	3.958	4.882	6.241	4.490	10.70	12.88	15.11	17.28	Flow			
	0.657	0.734	0.811	1.000	1.185	1.555	1.915	2.448	3.330	4.190	5.045	5.938	6.796	Drop			
1½	2.281	2.551	2.816	3.471	4.113	5.388	6.650	8.500	11.57	14.457	17.56	20.56	23.53	Flow			
	0.505	0.566	0.624	0.770	0.910	1.194	1.472	1.883	2.564	3.222	3.889	4.555	5.222	Drop			
2	3.760	4.208	4.641	5.721	6.782	8.880	10.96	14.02	19.06	24.02	28.92	33.90	38.80	Flow			
	0.334	0.376	0.412	0.509	0.602	0.788	0.976	1.243	1.690	2.160	2.562	3.110	3.448	Drop			
2½	5.365	6.000	6.621	8.165	9.680	12.68	15.64	20.00	27.20	34.26	41.28	48.36	55.35	Flow			
	0.250	0.280	0.309	0.382	0.452	0.592	0.713	0.933	1.270	1.598	1.926	2.260	2.585	Drop			
3	8.280	9.260	10.22	12.60	14.93	19.57	24.13	30.85	42.00	52.88	63.70	74.62	85.45	Flow			
	1.77	0.199	0.220	0.272	0.322	0.421	0.520	0.664	0.905	1.138	1.370	1.610	1.840	Drop			
4	14.26	15.96	17.61	21.70	25.73	33.70	41.58	53.15	72.33	91.10	109.8	128.6	147.2	Flow			
	0.118	0.133	0.146	0.181	0.214	0.279	0.345	0.441	0.600	0.755	0.911	1.068	1.235	Drop			
5	22.43	25.08	27.68	34.12	40.45	52.96	65.32	83.60	113.7	143.2	172.4	202.2	231.3	Flow			
	0.085	0.096	0.106	0.130	0.154	0.202	0.249	0.318	0.433	0.546	0.656	0.768	0.883	Drop			
6	32.36	36.22	39.95	49.25	58.38	76.48	94.30	120.7	164.2	206.7	249.0	291.8	334.0	Flow			
	0.066	0.074	0.082	0.101	0.119	0.156	0.193	0.247	0.336	0.422	0.508	0.597	0.683	Drop			
8	57.30	64.10	70.72	87.15	103.4	135.4	166.9	213.6	291.0	365.9	440.8	516.6	591.0	Flow			
	0.045	0.051	0.056	0.069	0.082	0.107	0.131	1.67	0.229	0.287	0.346	0.406	0.465	Drop			
10	90.40	101.1	111.6	137.6	163.1	213.6	263.4	336.8	458.5	577.2	695.0	815.0	932.8	Flow			
	0.034	0.038	0.042	0.052	0.061	0.080	0.098	0.126	0.171	0.214	0.258	0.304	0.348	Drop			
12	128.6	143.8	158.8	195.7	232.0	303.9	374.6	479.3	652.0	821.5	989.0	1159.0	1327.0	Flow			
	0.027	0.031	0.034	0.042	0.049	0.064	0.079	0.101	0.137	0.172	0.208	0.280	0.313	Drop			

*Courtesy Crane Company.

RESULTS OF LABORATORY EXPERIMENTS

The Research Laboratory of the AMERICAN SOCIETY HEATING AND VENTILATING ENGINEERS has investigated this subject[1], and has found the critical velocity for quiet operation to be about 22 in. per second for the sizes of pipe investigated and apparently increasing with the size of pipe. The maximum velocity, however, with counter flow of condensate where noise is not objectionable is considerably higher and increases rapidly with size of pipe. In the case of horizontal runs both the critical velocity for quiet operation and the maximum velocity where noise is not objectionable, depend upon the pitch of the pipe. The maximum capacity and velocity where noise is not objectionable for horizontal pipes with various pitches are given in Table 44.

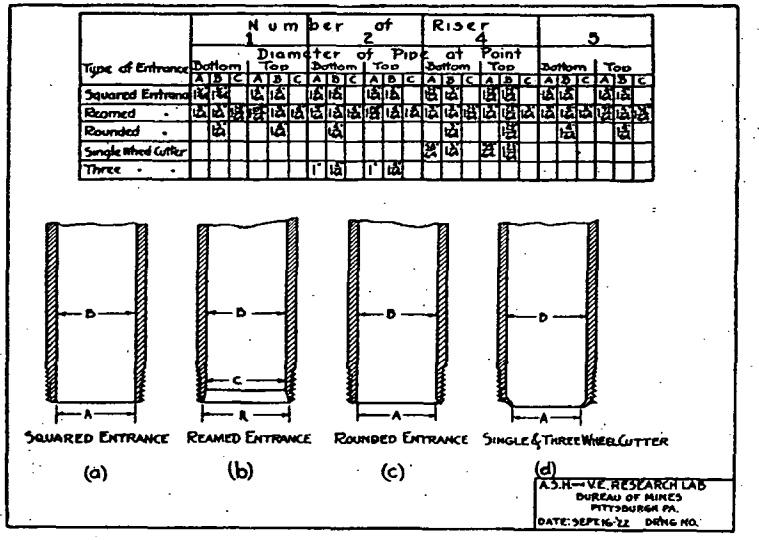


FIG. 22. EFFECT OF REAMING ENTRANCE TO ONE-PIPE RISERS

The capacity of risers with various shaped entrances is very important and those shown in Fig. 22 gave the following maximum capacities:—

		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

Where the velocity of steam is the limiting factor of the capacity of a pipe, care must be taken that this velocity is not exceeded in any part of

[1]Reports by Houghten & Ebin, TRANSACTIONS, AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS, Vols. 28-32, incl.

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 dope constricting it at joints. Iron pipe should also be examined for constricting blisters, Fig. 22 and Table 46, from the Laboratory reports already mentioned show the importance of these factors.

Table 46 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.

TABLE 44. MAXIMUM 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

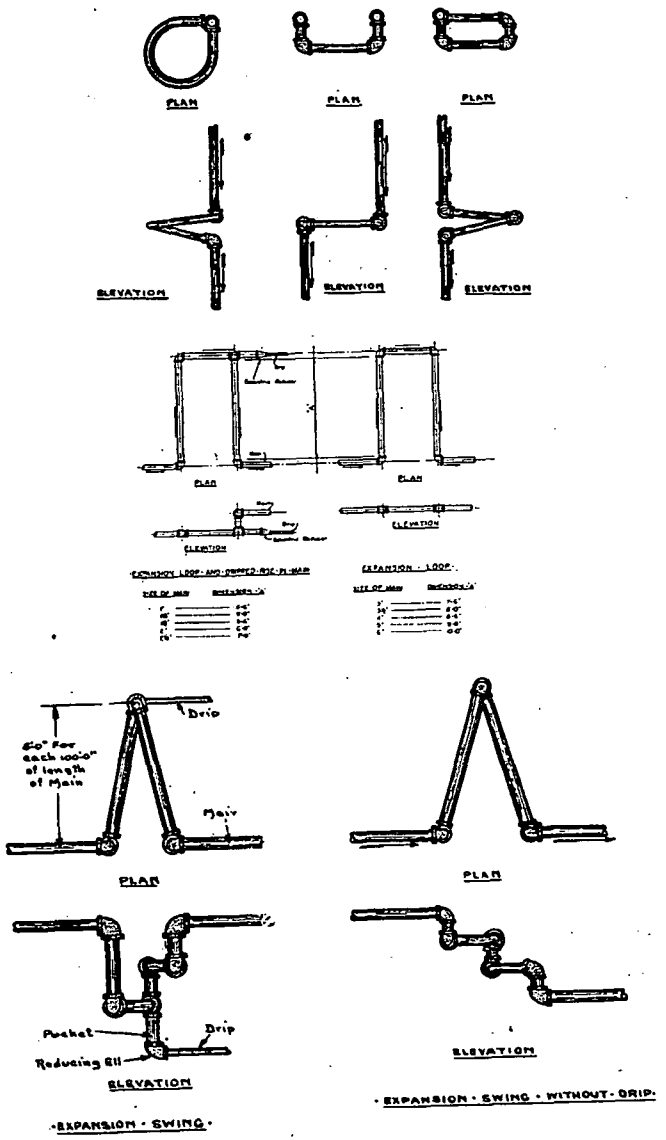
TABLE 45. RESULTS OF TESTS ON ANGLE AND GLOBE VALVES

Nominal Size of Pipe In.	Area of Pipe Sq. In.	Area Valve Seat Opening Sq. In.	Per Cent of Area of Pipe	Maximum Pipe and Valve	Capacity Pipe Alone	Per Cent of Capacity of Pipe Alone
¾	0.537	0.4418	82.2	9.68	13.52	71.6
1	0.835	0.822	98.4	22.10	23.30	95.0
1¼	1.459	1.258	86.2	30.00	47.5	63.1
1½	1.927	1.773	92.2	46.13	68.5	67.4

Nominal Size In.	Valve Stem—Vertical		Valve Stem—Horizontal	
	Capacity of Pipe and Valve Lb. per Hr.	Per Cent of Capacity of Pipe Alone	Capacity of Pipe and Valve Lb. per Hr.	Per Cent of Capacity of Pipe Alone
¾	1.38	11.8	8.83	76.3
1	7.73	35.7	14.06	66.1
1¼	13.20	31.2	22.88	54.3
1½	18.81	33.0	32.00	56.7

TABLE 46. 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



Note.—Allowance for expansion must be made in long runs of mains both vertical and horizontal. One expansion joint or swing should be installed in any run over 100 ft. 0 in. long and one for each additional 100 ft. 0 in. of run. All branch connections should be made so as to allow a swing both at the main and the other end connections.

FIG. 23. TYPICAL EXPANSION CONNECTIONS FOR RISERS

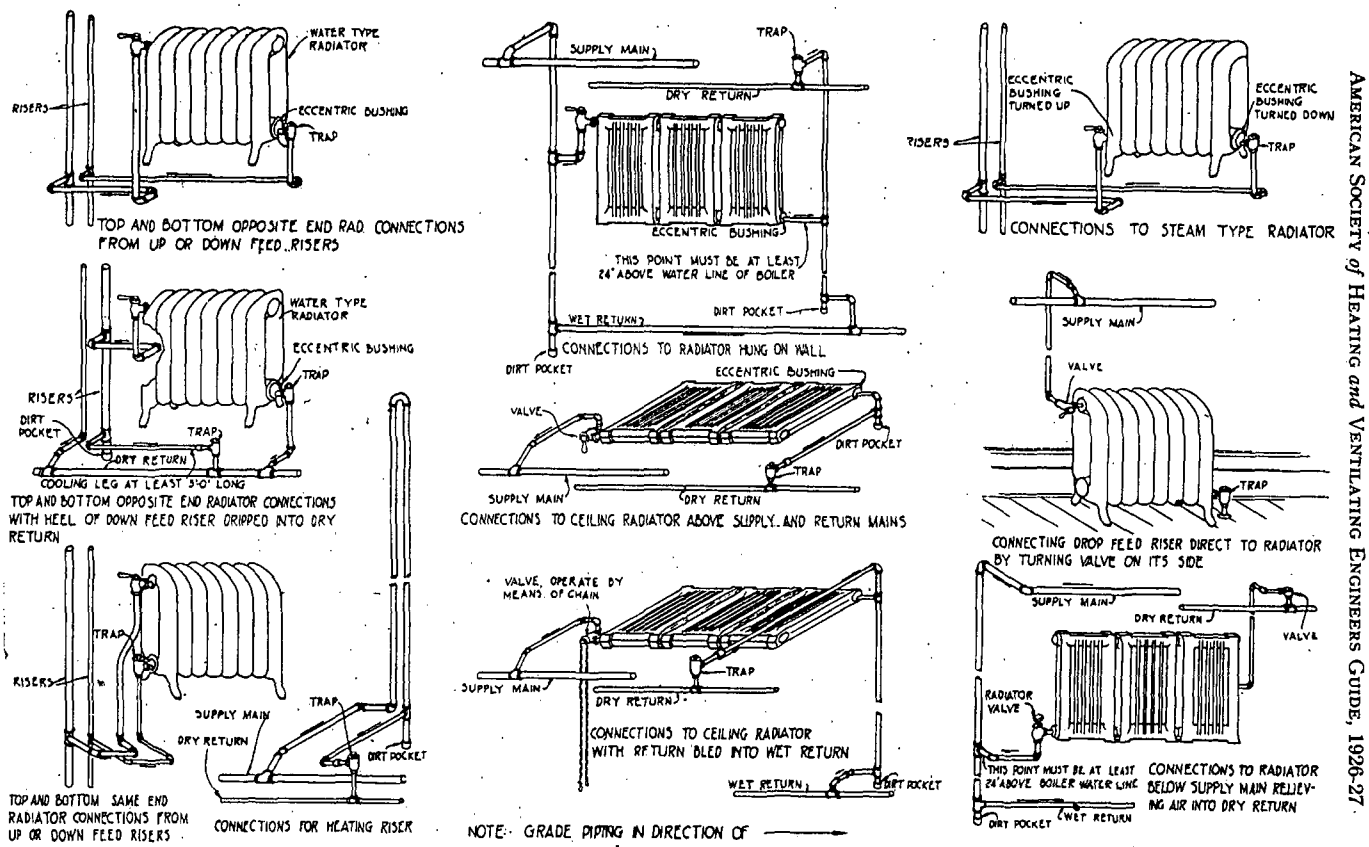


FIG. 24. TYPICAL RADIATOR CONNECTIONS FOR STEAM HEATING SYSTEMS

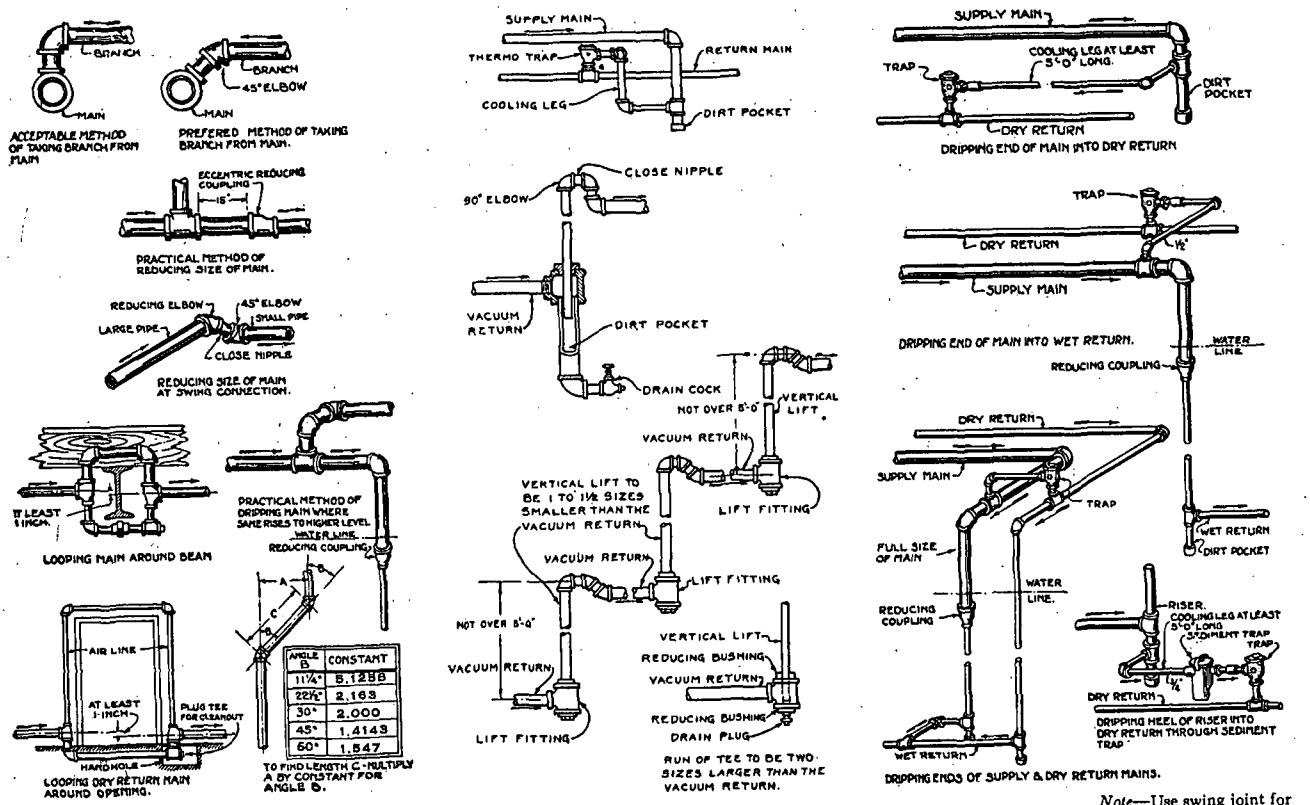


FIG. 25. TYPICAL STEAM PIPING CONNECTIONS

Note—Use swing joint for expansion when possible.

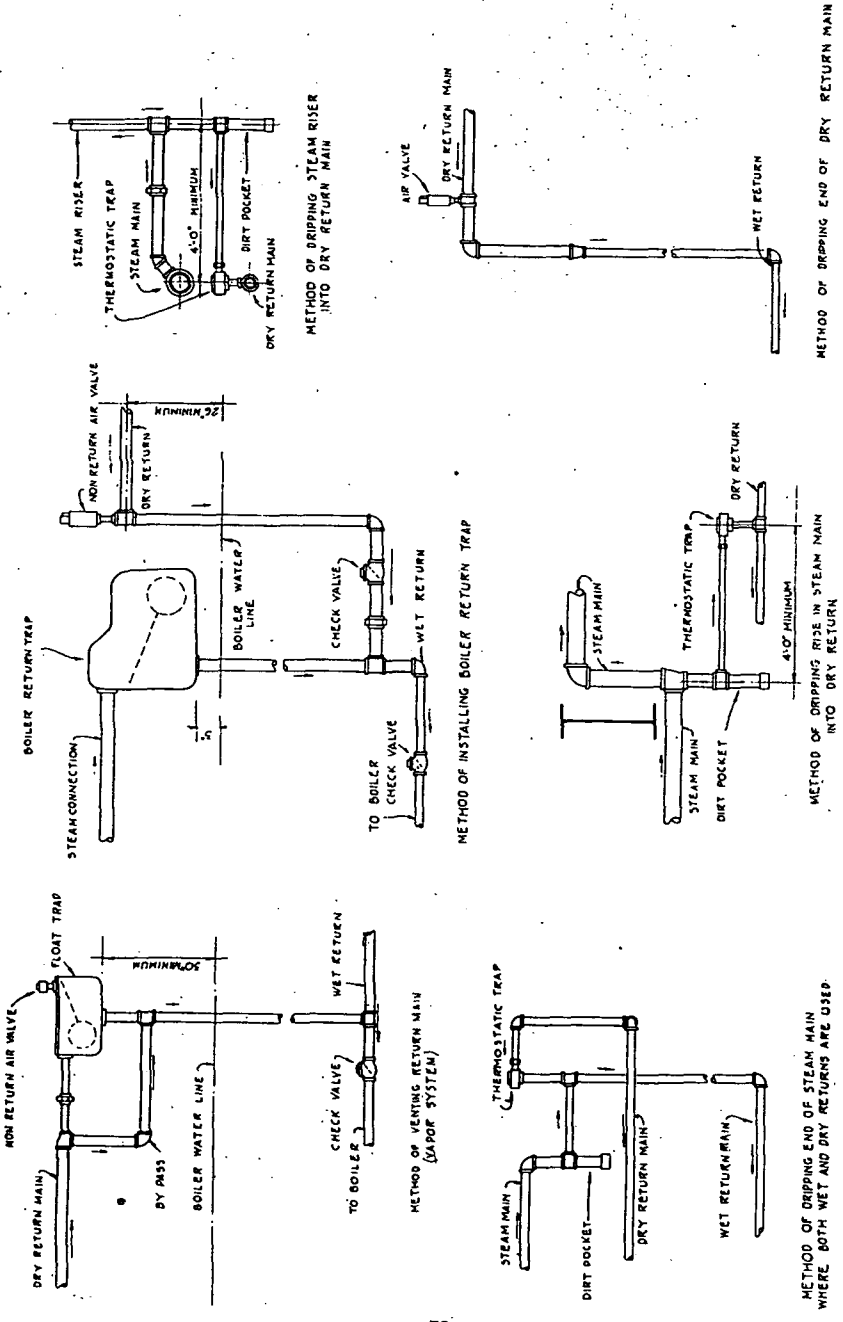


FIG. 25A. TYPICAL STEAM PIPING CONNECTIONS

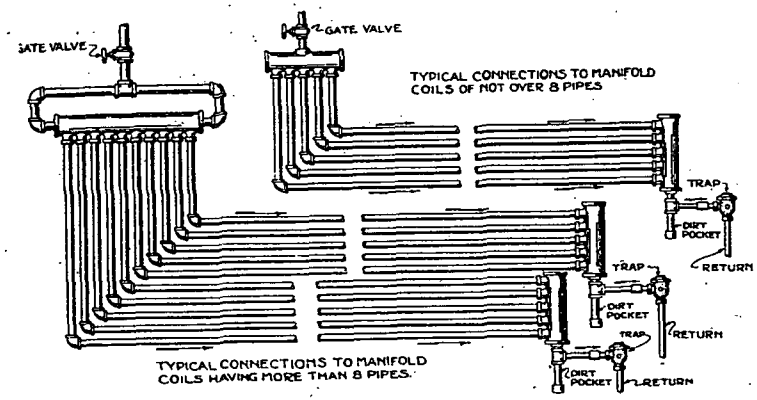
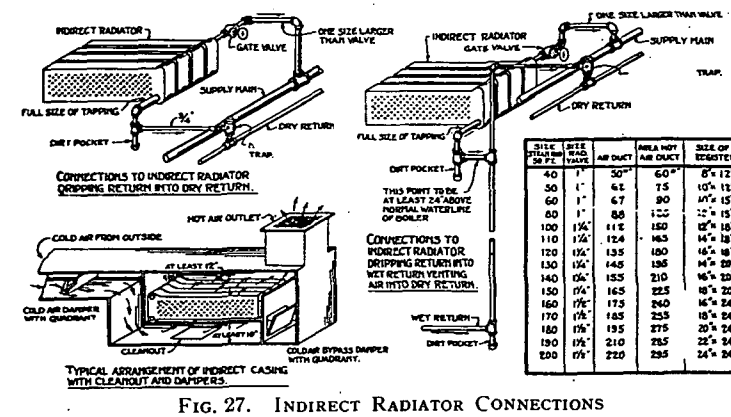
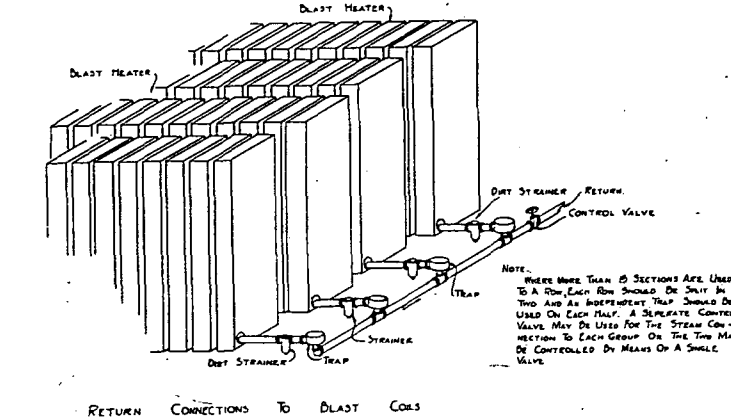


FIG. 26. TYPICAL CONNECTIONS TO MANIFOLD COILS HAVING MORE THAN 8 PIPES



SIZE RADIATOR 38 P.E.	SIZE RAD. VALVE	AIR DUCT	AREA HOT AIR DUCT	SIZE OF REGISTER
40	1"	50"	60"	8"x 12"
50	1"	62	75	10"x 12"
60	1"	67	90	11"x 15"
80	1"	88	120	12"x 15"
100	1¼"	112	150	15"x 15"
110	1¼"	124	165	14"x 18"
120	1¼"	135	180	16"x 18"
130	1¼"	145	195	14"x 22"
140	1¼"	155	210	16"x 22"
150	1¼"	165	225	18"x 20"
160	1½"	175	240	16"x 24"
170	1½"	185	255	18"x 24"
180	1½"	195	275	20"x 24"
190	1½"	210	285	22"x 24"
200	1½"	220	295	24"x 24"

FIG. 27. INDIRECT RADIATOR CONNECTIONS



RETURN CONNECTIONS TO BLAST COILS

FIG. 28. RETURN CONNECTIONS TO BLAST COILS

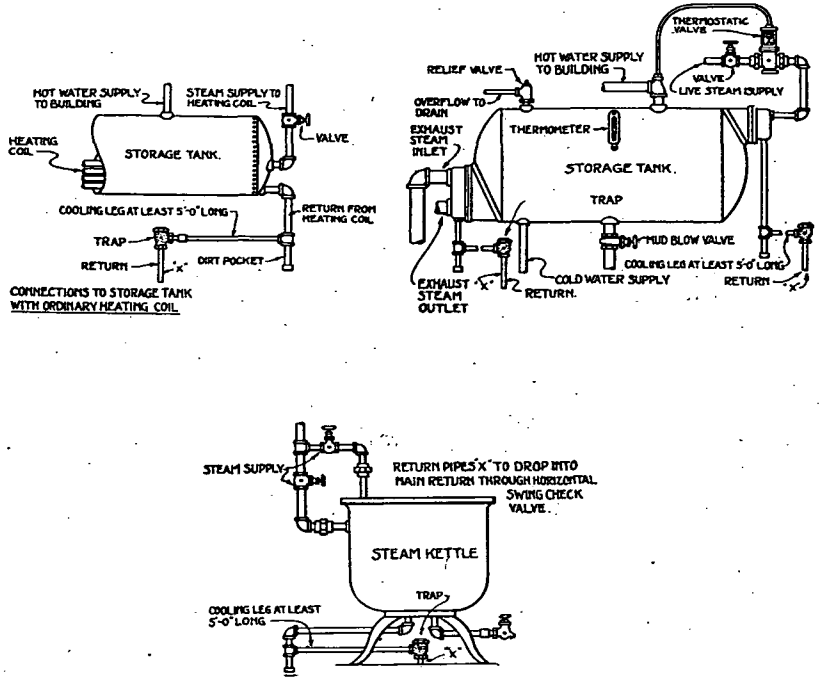


FIG. 29. CONNECTIONS TO COILS IN TANKS

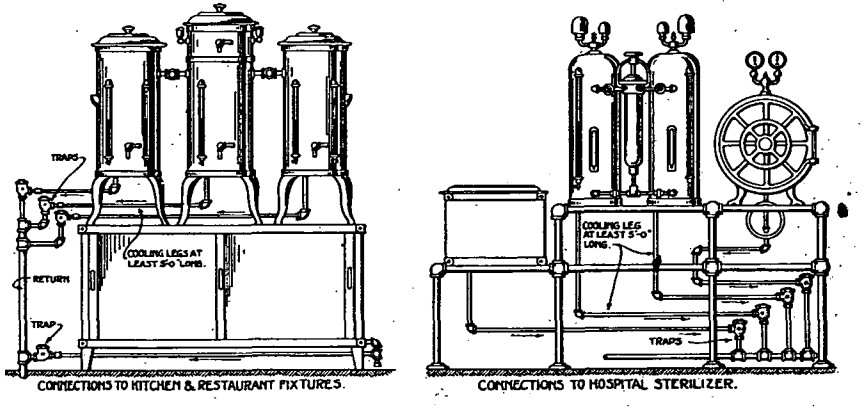


FIG. 30. TYPICAL CONNECTIONS TO KITCHEN AND HOSPITAL EQUIPMENT

CHAPTER IV

SYSTEMS AND PIPING FOR HOT WATER HEATING

A HOT WATER HEATING SYSTEM consists essentially of heaters, radiators, and a connecting system of pipe through which water circulates while conveying heat from the heater to the radiators.

The connecting pipe lines should be arranged and proportioned so that every radiator will receive its proper share of heat when the total quantity of heat required by all the radiators is being delivered to the water at the heater. There are a large number of systems or methods of arranging the pipe lines in a hot water system. A few are indicated in Fig. 31.

The force maintaining circulation is either that of gravity, which acts because the water in the return risers is heavier than the water in the supply risers, or the force supplied by a pump placed in the return main near the heater. When circulation is due to gravity, it is called a *Gravity System;* when circulation is produced by a pump, it is called a *Forced-Circulation System.*

OPEN AND CLOSED SYSTEMS

Hot water heating systems may be either open or closed. Open systems have expansion tanks vented to the atmosphere. Closed systems are operated under pressures higher than atmospheric.

In designing the pipe lines for a *Closed System* the same methods and formulas are used to determine the pressure heads and friction heads as are used in designing an *Open System.*

The principal difference between a closed system and an open system is that in a closed system, the pressure on the water in the system can be regulated by a set of valves whereas, in an open system, the pressure on the water is only that due to the atmosphere and the column of water extending from the expansion tank to the point where the pressure is measured. In general, the pressure on the water is higher in a closed system than in an open system and, consequently, the water can be heated to a higher temperature in the former without boiling. As the temperature of the water in a heating system is increased, the size of the radiation and of the pipe lines, necessary to supply a given quantity of heat, is decreased. An open system can be made the equivalent of a closed system in this respect by elevating the expansion tank to a sufficient height. For example, if, in a closed system, a pressure of

Chapter especially prepared for THE GUIDE by F. E. Giesecke, professor of mechanical engineering, University of Texas, Austin, Texas.

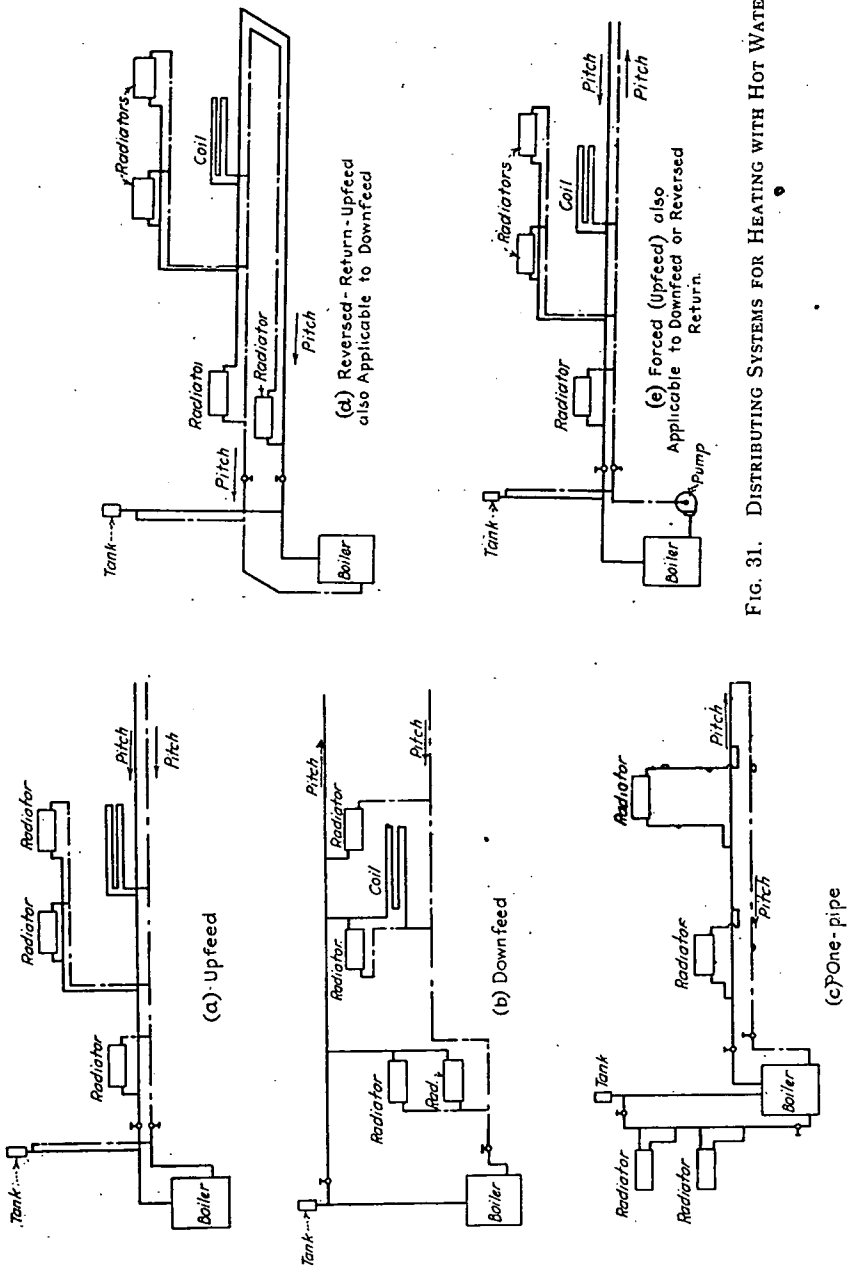


FIG. 31. DISTRIBUTING SYSTEMS FOR HEATING WITH HOT WATER

15 lb. per square inch is maintained in the highest radiator and if, in an open system, the expansion tank is located 15 x 2.4 or 36 ft. above the highest radiator, the two systems will be alike so far as pressure and boiling points are concerned.

Since water is only very slightly compressible (a change in pressure of 10 lb. per square inch will produce a change in volume of about 1 in 33,000) its density and its coefficient of friction may be considered independent of pressure and hence the laws governing pressure heads and friction heads are also independent of pressure and are the same for closed systems as for open systems.

PRESSURE HEAD

The force maintaining circulation is sometimes expressed in pounds per square inch but more generally in terms of the height of a column of water which would produce this pressure, *i. e.* in feet of water, millinches of water, etc. The height of such a column of water is the *Pressure Head.*

FRICTION HEAD

The forces resisting circulation are the frictional resistances in the heater, the radiators, the pipe lines, the several fittings and valves, and in the water itself. These resisting forces are also expressed in terms of water column. The height of this column is the *Frictional Head.*

Tests by Professor F. E. Giesecke demonstrate that the friction head for new commercial black iron pipe of American manufacture is

$$h = 83\ V^{1.88}\ d - 0.04\ d - 1.275$$

where

h = friction head, per foot of pipe, in millinches of water,
V = velocity, in ft. per sec.
d = actual internal diameter of pipe, in inches.

It has been found by experiment that the friction of water in commercial black iron pipe varies, approximately, as the 1.8 power of the velocity and that the friction in fittings, valves, and in radiator and heater inlets and outlets varies, approximately, as the square of the velocity of the water in a pipe having the same nominal size as such fitting, valve, etc. It is, therefore, impossible, to express with accuracy the friction in a pipe fitting in terms of the friction in the pipe. For example, if the friction in an elbow is equal to the friction in 3 ft. of pipe, when the velocity of the water is 1 ft. per second, the friction in the elbow will be equal to that in 4.1 ft. of pipe when the velocity is 5 ft. per second, and equal to that in 2.2 ft. of pipe when the velocity is 1/5 ft. per second.

It is possible, however, to express, with sufficient accuracy, the friction in one pipe-fitting in terms of the friction in any other pipe-fitting or in any valve. For example, if the friction in one open globe valve is equal to that in twelve elbows, when the velocity is 1 ft. per second, the same relation will exist at all other velocities, if the friction varies as the

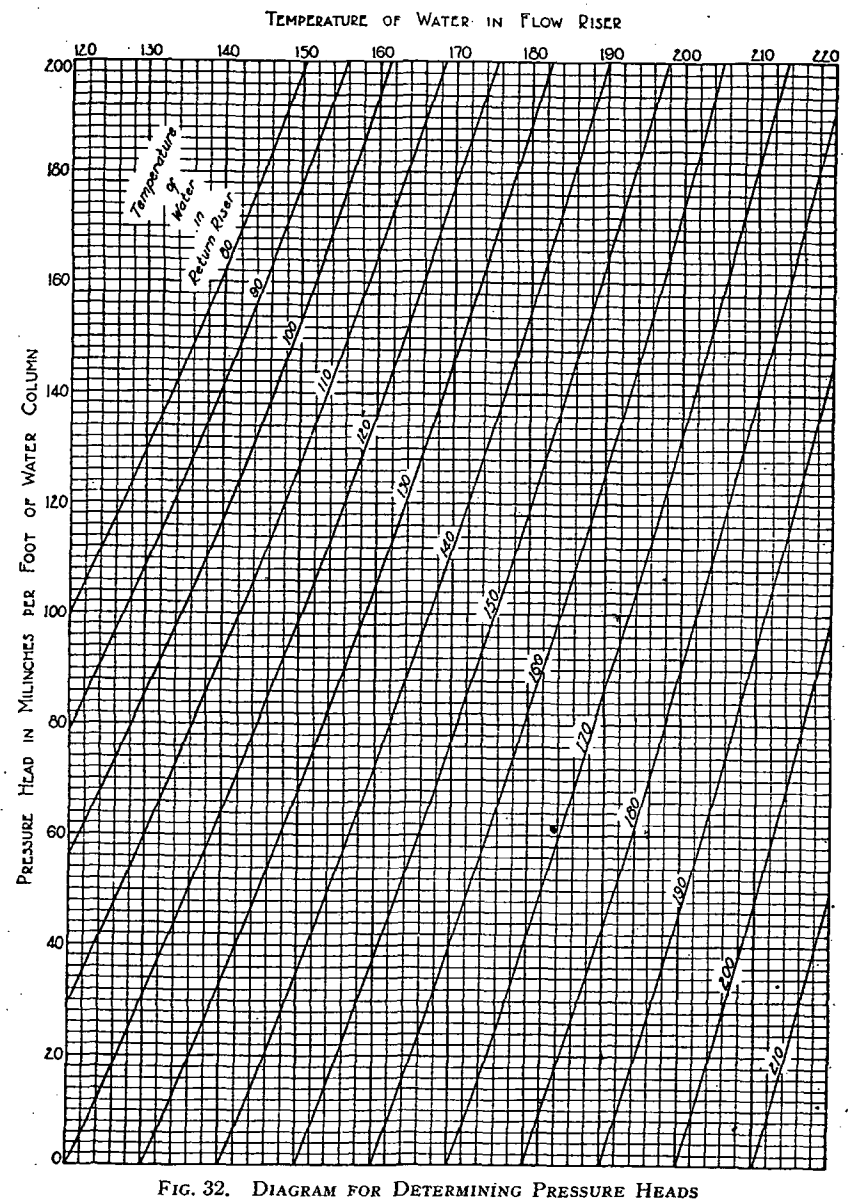


FIG. 32. DIAGRAM FOR DETERMINING PRESSURE HEADS

square of the velocity in both cases. Since more 90 deg. elbows are used in hot water heating systems than any other type of fitting or any valve, all fittings, valves, and other obstructions, found in radiator circuits, shall be expressed in terms of elbow equivalents, for the determination of their friction heads. For this purpose the following table of equivalents may be used:[1]

1 90 deg. elbow	1.0	1 Open globe valve	12.0
1 45 deg. elbow	0.9	1 Angle radiator valve	2.0
1 Open return bend	1.0	1 Radiator	3.0
1 Tee	2.2	1 Heater	3.0
1 Open gate valve	0.5		

To avoid friction head calculations by complicated formulae, the diagram of Fig. 33 may be used to find the friction head in one foot of pipe, as the diagram of Fig. 34 is used to find the friction head in one elbow.

GRAVITY SYSTEM

The pressure head for any radiator or group of radiators, in a gravity-flow system, shall be determined by calculating the maximum difference in the pressures caused by the water in the flow and return risers and dividing this difference by the density of water whose temperature is the mean of the temperatures of the water in the flow and return risers. To illustrate: If a radiator is located above the flow main so that its risers are 12 ft. high, and if the temperature of the water in the flow and return risers is, respectively, 180 and 160 deg., and if the density of water at 180, 170 and 160 deg. is, respectively, 60.58, 60.80, and 61.00 lb. per cu. ft., the maximum difference in the pressures caused by the water in the two risers is 12 (61.00 − 60.58) or 5.24 lb. per sq. ft.; the corresponding pressure head is 5.24/60.80, or 0.0829 ft., or 995 m.i. of 170 deg. water.

Instead of calculating the pressure head, it may be determined, with sufficient accuracy, from Fig. 32. To illustrate: For the example cited, find 180 on the upper margin of the diagram; from there traverse vertically downward to the intersection with the inclined 160 deg. line; from there, horizontally to the left margin and read 82 m.i. per foot of water column; multiply by 12, the height of the risers in feet, and find 984 m.i. of 170 deg. water, which differs only by about 1 per cent from the head calculated previously.

After the general arrangement of the pipe lines has been decided upon, the pipe sizes are determined so that, for any radiator or group of radiators, the friction head is equal to the pressure head when the system is operating at a uniform or constant rate.

The friction head for any radiator or group of radiators should be determined by calculating and adding together the friction heads in the heater, radiator, pipes, pipe fittings, and valves which constitute the circuit for that radiator or group of radiators.

[1]These values are based, with slight modifications suggested by later research, on experimental determinations by F. E. Giesecke and published in *Domestic Engineering*, November, 1912. A record of these tests is shown in Harding and Willard, *Heating and Ventilating*, p. 259 and in Marks, *Machine Design*, pp. 239–240.

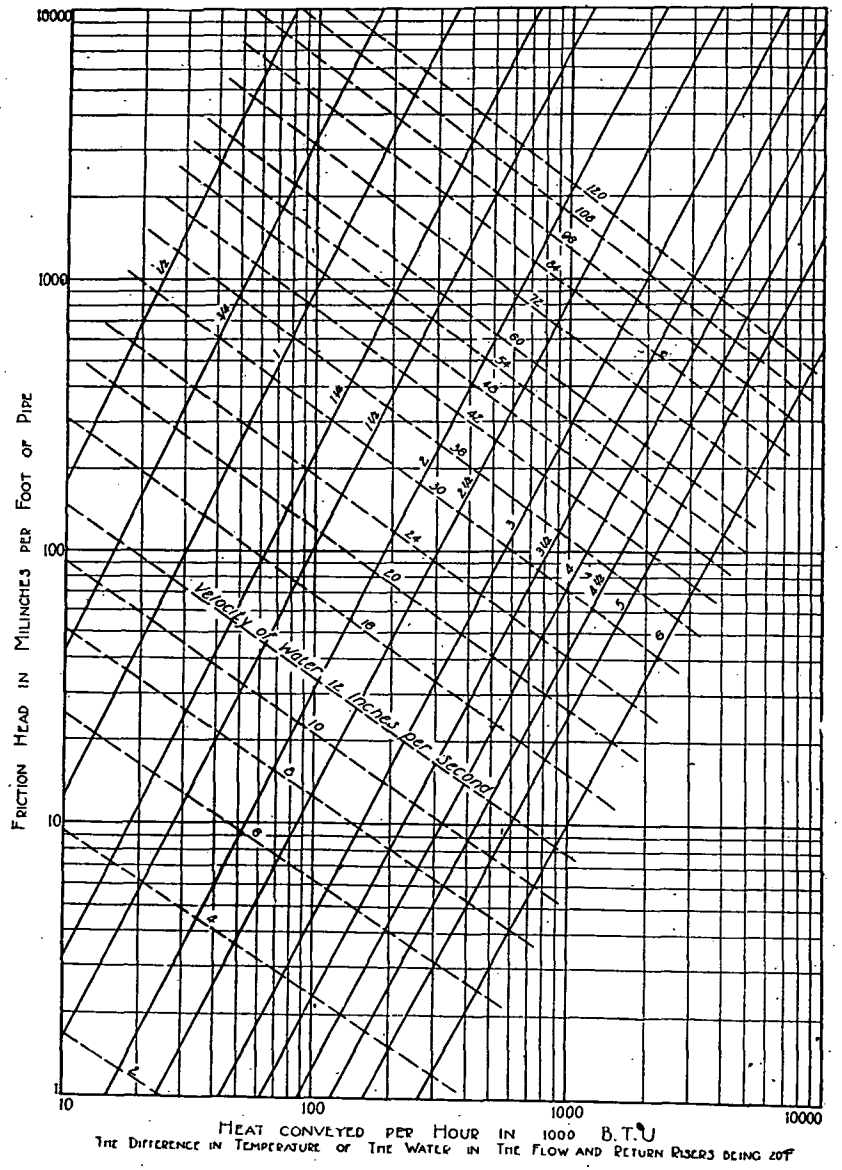


FIG. 33. CHART FOR FINDING FRICTION HEAD PER FOOT OF PIPE

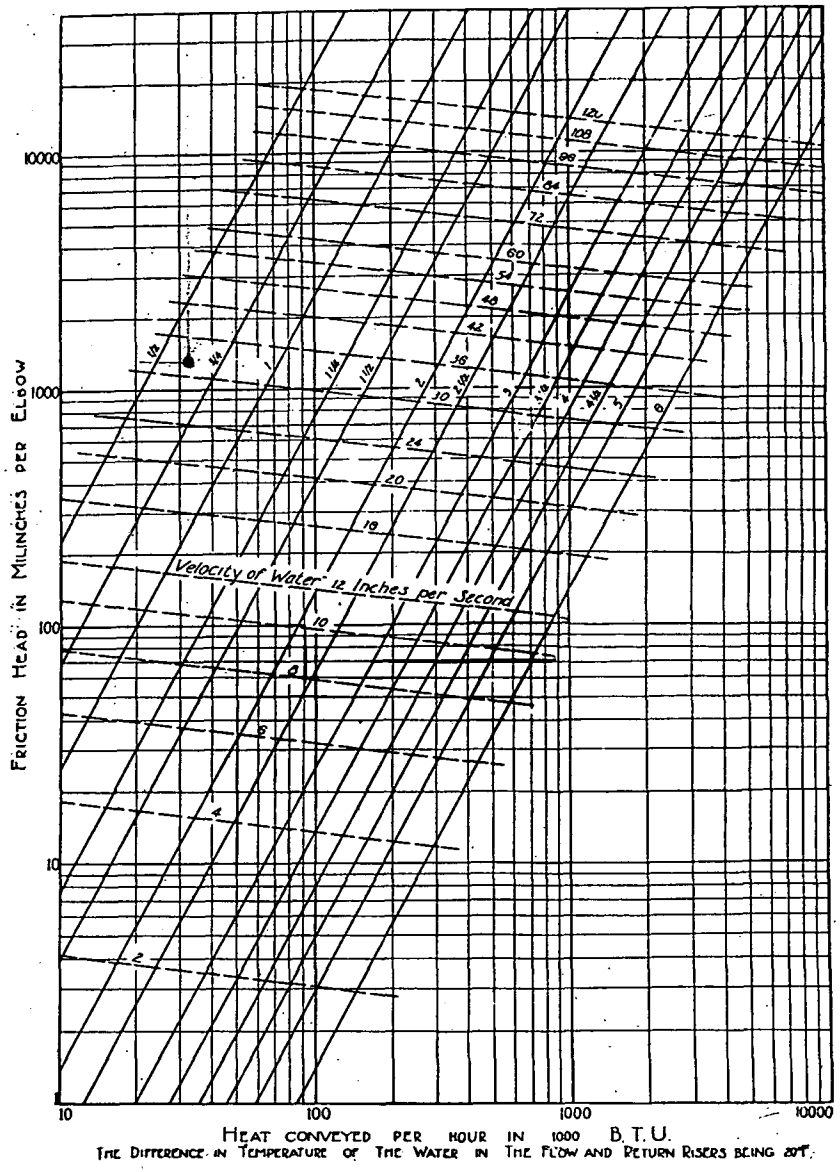


FIG. 34. CHART FOR FINDING THE FRICTION HEAD PER ELBOW

Gravity hot water heating systems may be designed for even circulation at any range of water temperature difference between flow and return, within practical limits. Small differences in temperature result in large pipe sizes, uneconomical both in cost of installation and operation, and slowness to respond to outside temperature changes. Large differences in temperature result in undesirable small piping and difficulty in balancing for circulation. While gravity systems have been designed and installed on as low as 10 deg. and as high as 60 deg. difference, best results are obtained for difference between 20 and 30 deg. with 20 deg. difference applicable to most conditions.

The calculations of pipe sizes to the radiator most unfavorably situated on the basis of one or more different temperature differences will usually make the best practical temperature difference evident. The criterion which determines whether one radiator is more unfavorably or favorably situated than another is the value of the quotient when the height of the center of the radiator above the center of the boiler in feet is divided by the total travel of the water through the radiator in question.

In selecting approximate pipe sizes the following Table 47 may be used:

TABLE 47. APPROXIMATE PIPE SIZES FOR GRAVITY CIRCULATION FOR A TEMPERATURE DROP OF 20 DEG. AND FOR VELOCITIES RANGING FROM 2 TO 6 IN. PER SECOND

Pipe Size	Capacity in 1000 B.t.u.
½″	1.5 to 4.6
¾″	2.7 " 8.1
1″	4.4 " 13.1
1¼″	7.6 " 22.7
1½″	10.3 " 30.9
2″	16.9 " 50.8
2½″	24.2 " 72.5
3″	37.3 " 111.8
3½″	49.9 " 149.6
4″	64.3 " 192.9
4½″	80.7 " 242.0
5″	102.0 " 306.0
6″	146.0 " 438.0

The capacities shown in the table vary directly with the temperature drop and the velocity. Since the velocity depends on the pressure head and on the friction head it cannot be predicted or estimated accurately before the system is designed and, consequently, Table 47 must be used only for very approximate determinations of pipe sizes.

A much better approximate determination of pipe sizes may be made by the following method:

1. Determine the equivalent length of the circuit by adding the length of the pipe in the circuit to the equivalent length of the elbow equivalents, placing each elbow equivalent equal to a pipe whose length is equal to 24 diameters.

2. Determine from Fig. 32 the pressure head for the circuit and divide it by the equivalent length of the circuit to find the average friction head of the circuit in millinches per foot of pipe.

3. Determine from Fig. 33 which pipe size has that particular unit friction head when the given quantity of heat is being conveyed.

To illustrate the application to practice, let it be required to determine the sizes of a few of the pipes for the hot-water heating system shown in Fig. 35.

This system is intended for a three-story building in which all rooms are to be heated to 70 deg. The first floor radiator is to dissipate 10,000 B.t.u., the second floor radiator, 8000 B.t.u., and the third floor radiator, 12,000 B.t.u., per hour.

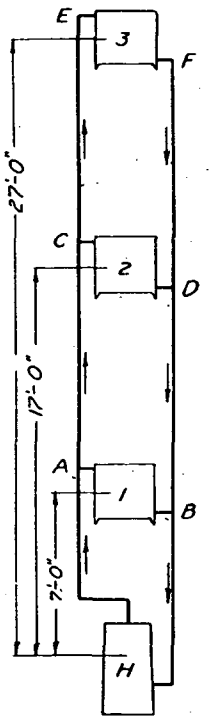


FIG. 35. GENERAL ARRANGEMENTS OF HEATING SYSTEM

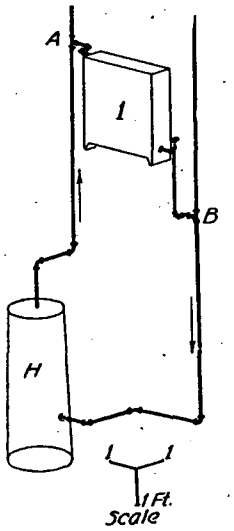


FIG. 36. DIAGRAM FOR SIZING PIPES

The system is piped so that water, leaving the heater, may take any one of three paths, through Radiator, 1, 2 or 3. The correct solution of the problem requires that the three paths be so proportioned that the proper quantity of water will flow through each of the three radiators.

Proceed with the design as follows:

1. Divide the three circuits of the system into sections so that every section will contain only one pipe size and only one rate of flow of heat. For example, the circuit of Radiator I should be divided into four sections; the first section extending from H to A; the second from A to 1; the third from 1 to B; and the fourth from B to H. The point A must be the

division point of two sections because the Section *H-A* conveys the heat for all three radiators, whereas Section *A*-1 carries only the heat for Radiator 1.

For a similar reason *B* must be a division point. The reason for selecting 1 as a division point is that it is often necessary to select a different pipe size for Section *A*-1 than for Section 1-*B*, in order to secure the proper friction head for Radiator 1. If it were certain that the pipe size for Section *A*-1 could be the same as that for Section 1-*B* the pipe line from *A* to *B* could be called one section; since it is impossible to know in advance what the pipe sizes leading to and from the radiator must be, it is best to make the radiator the division point of two sections.

2. Having divided the several circuits into sections prepare a table, like Table 48, and record there the designations of the several sections, the quantity of heat conveyed by each section, and the number of feet of pipe and the number of elbows or elbow equivalents in each section. All of this information should be obtained from the plans for the heating system. In Fig. 35 is shown only a diagrammatic representation of the system to illustrate the general arrangement. In this case a number of elbows, valves, air valves, and the expansion tank are omitted in order to simplify the drawing. For the actual design, a complete drawing, such as that shown in Fig. 36, must be available or the designer must be sufficiently familiar with the proposed installation to be able to insert the correct pipe length and the correct number of elbows or elbow equivalents in the description of each section, as recorded in Table 48.

3. Calculate the pressure head available for the circuit by means of Fig. 32 and record it in the table.

4. Calculate the pipe sizes for the several sections by means of Figs. 33 and 34 so that the sum of the friction heads in all the sections composing any one circuit is equal to the pressure head available for that circuit.

TABLE 48. CIRCUIT I*

Pressure head = 7 × 90 = 630 *m.i.*

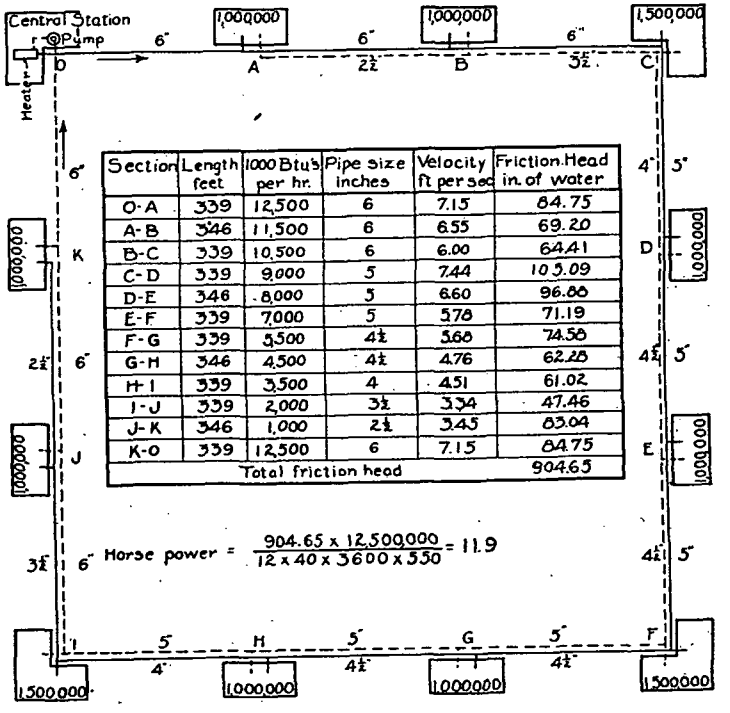
SECTION	B.T.U.	FEET ELBOWS	ASSUMED DIAMETER IN.	UNIT FRICTION	TOTAL FRICTION	SELECTED DIAMETER IN.	UNIT FRICTION	TOTAL FRICTION
H-A	30,000	8.67 3.5	1½	12	104 122	1½	.....	104 122
A-1	10,000	1.2 5.5	1¼	35 3.5	4 41	1¼		4 41
1-*B*	10,000	2.67 7.5	1	7.5 12.5	33 183	1¼	3.5 7.5	9 56
B-H	30,000	10.7 4.5	1½	24.5 12 35	128 157	1½		128 157
Total					772			621

*The calculations for Circuits II and III are made and recorded in a similar manner.

FORCED CIRCULATION

In designing the pipe lines for forced-circulation systems, the same methods and formulas are used to determine pressure heads and friction heads which are used in the design of gravity-flow systems, with the one exception that in forced-circulation systems the force producing the necessary pressure head is supplied partly or entirely by a pump.

The designing engineer should determine, in every case, what portion, if any, of the force necessary to produce the required pressure head



Section	Length feet	1000 Btu's per hr.	Pipe size inches	Velocity ft per sec	Friction Head in. of water
O-A	339	12,500	6	7.15	84.75
A-B	346	11,500	6	6.55	69.20
B-C	339	10,500	6	6.00	64.41
C-D	339	9,000	5	7.44	105.09
D-E	346	8,000	5	6.60	96.86
E-F	339	7,000	5	5.78	71.19
F-G	339	5,500	4½	5.60	74.58
G-H	346	4,500	4½	4.76	62.28
H-I	339	3,500	4	4.51	61.02
I-J	339	2,000	3½	3.34	47.46
J-K	346	1,000	2½	3.45	83.04
K-O	339	12,500	6	7.15	84.75
Total friction head					904.65

FIG. 37. CENTRAL HOT WATER HEATING SYSTEM SUPPLYING GROUP OF ELEVEN BUILDINGS

will be supplied by gravity. For example, in a central heating system, the pump may supply the entire pressure head for the distributing mains while gravity may supply all or part of the pressure head for the service lines in the several buildings.

In forced-circulation systems, the pressure head caused by the difference in density of the water, and which maintains circulation in gravity-flow systems, is generally small when compared with the pressure head

produced by the pump. It may be neglected in the design if it is less than 20 per cent of that produced by the pump.

To illustrate, let it be required to determine the pipe size for the central hot-water heating system shown in Fig. 37.

The system is to supply 12,500,000 B.t.u. per hour to a group of eleven buildings with a temperature drop of 40 deg. The system is provided with a reversed return. The pipe sizes are selected so that the friction heads in the eleven circuits are practically equal. The

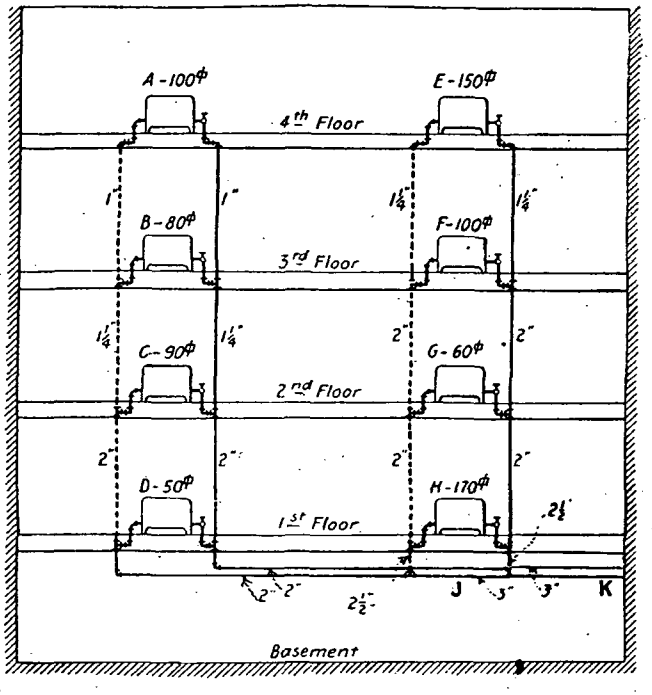


FIG. 38. LAYOUT FOR SIZING HOT WATER MAINS

velocity of the water varies from 3⅓ to 7½ ft. per second. The theoretical horsepower required to circulate the water through the main is 11.9. The table in Fig. 37 shows the calculations for one of the eleven circuits.

If the circulation within the buildings is maintained by the pump, the power required therefor must be added to that already calculated. Each flow and return pipe, connecting a building and the mains, should be provided with a gate valve and a thermometer and the gate valves should be adjusted so that the temperature drop in each of the eleven buildings is 40 deg.

SIMPLE RULE FOR SMALL GRAVITY SYSTEMS

In designing a hot-water system for a residence or other small buildings the following simplified method by N. S. Thompson and C. A. Fuller gives good results for the usual two-pipe basement main system.

Determine the size of radiator tapping and connection from Table 49 and the size of riser and main from Table 50.

To illustrate assume the layout in Fig. 38. The radiator connections determined from Table 49 are as follows:

$A = 1$ in.	$E = 1\frac{1}{4}$ in.
$B = 1$ in.	$F = 1\frac{1}{4}$ in.
$C = 1\frac{1}{4}$ in.	$G = 1$ in.
$D = 1$ in.	$H = 1\frac{1}{2}$ in.

Where one radiator only is supplied the riser and mains are sized the same as the radiator connection. Where more than one radiator is supplied the pipe size is determined from Tables 49 and 50 as follows:

$A = 1$ in. $= 10$ Equivalent carrying capacity
$B = 1$ in. $= 10$ " " "

$20 = 1\frac{1}{4}$ in. pipe between D and C
$C = 1\frac{1}{4}$ in. $= 20$ Equivalent carrying capacity

$40 = 2$ in. pipe between D and C
$D = 1$ in. $= 10$

$50 = 2$ in. pipe between J and D

Proceeding in like manner the other sections of pipe are found to be as follows:

E to $F = 1\frac{1}{4}$ in.	H to Mains $= 2\frac{1}{2}$ in.
F to $G = 2$ in.	J to $K = 3$ in.
G to $H = 2$ in.	

TABLE 49. HOT WATER SYSTEM PIPE SIZES AND CONNECTIONS

PIPE SIZE	FIRST FLOOR	SECOND FLOOR	THIRD FLOOR	FOURTH FLOOR
¾"	40	50	60	70
1"	70	80	90	100
1¼"	110	120	135	150
1½"	180	195	210	230
2"	300	350	400	500

In connection with Table 49, the following equalizing Table 50, should be used to determine the size of risers and basement mains.

TABLE 50. EQUALIZING TABLE FOR SIZING RISERS AND MAINS

SIZE OF PIPE	EQUIVALENT CARRYING CAPACITY	SIZE OF PIPE	EQUIVALENT CARRYING CAPACITY
½″	2	3″	175
¾″	5	3½″	260
1″	10	4″	380
1¼″	20	5″	650
1½″	30	6″	1050
2″	60	7″	1600
2½″	110	8″	2250

CHAPTER V

GREENHOUSE HEATING SYSTEMS*

GENERALLY speaking greenhouses are heated either by hot water or steam systems, both being used in all forms: gravity hot water; accelerated circulation of hot water, i.e., where there is some circulation due to gravity and an accelerator or impeller is used to accelerate that circulation; forced circulation of hot water; gravity low pressure steam; gravity low pressure steam with return by means of automatic steam pump and return by means of an electrically driven automatic pump; vacuum return systems; high pressure steam systems with high pressure in mains and reduced pressures in the coils in the houses and even in some odd cases by high pressure steam throughout. There are countless modifications of all of these systems.

Hot water heating is older, simpler and the more common method in small houses and small ranges of greenhouses.

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 plant.

For instance—the highest temperatures in greenhouses are required at night, whereas with residence systems the maximum temperatures are required in the day time.

Greenhouse fires are banked during the day almost always throughout the firing season, even in midwinter when the sun is shining, and fuel consumption is heaviest at night; 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 co-efficient 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 any other form of radiation in quiet air; its surplus must be greater than with boilers for any other sort of quiet air heating.

The usual boiler ratings, inflated as they many times are for residence heating purposes, must be discounted still more for greenhouse work, especially so where there is no night fireman, as with the smaller plants, and where fires are left for long periods without attention.

*Greenhouse heating section prepared by F. J. Elder, Irvington, N. Y.

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; 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, and expansion joints used where expansion may not be compensated otherwise.

TABLE 51. TEMPERATURE REQUIRED FOR DIFFERENT PURPOSES

HOUSE	TEMP. REQUIRED, DEG. FAHR.
General Purposes	55 to 60
Cool Greenhouse (Show)	45 " 60
Forcing House	60 " 65
Tropical, or Stove H	65 " 70
Conservatory (General Collection) (Winter Garden)	60 " 65
Palm House	60 " 65
Tropical Palm House	65 " 70
Cool Palm House	50 " 55
Orchid House	65 " 70
Cool Orchid House	50 " 55
Rose House	55 " 60
Carnation House	45 " 55
Violet House	40 " 45
Propagating House	55 " 60
Camelias and Azaleas	45 " 50
Cool Vinery	Cool and Damp
Early Vinery (Start January and February)	65 to 70
Second Vinery (Start February and March)	65 " 70
Late Vinery	65 " 70
Cool Peach House (Cold Damp Weather), Early Peach House (Start January and February)	65 " 70
Second Peach House (Start February and March), Late Peach House (Ripen November and December)	65 " 70
Tomato and Cucumber House	65 " 70
Lettuce House	40 " 45
Mushroom House	55 " 60
Fern House	60 " 65

The matter of levels also affects the design and proportions of the heating mains. In many greenhouse ranges the walk levels are not more than 2 ft. 6 in., or 3 ft., above the top of the boiler and where all of the radiating surface is made up of pipe coils on a level not higher than 1 ft. 6 in. above the floor, especially if there are short benches requiring short coils under them, special care is necessary to avoid short circuiting, or interference with the flow through low temperature drops in the short coils.

The temperatures required in houses are given in Table 51.

ESTIMATING HEATING REQUIREMENTS

Heating requirements, i.e., the amounts of radiation for greenhouses, are not obtained by scientific calculation or intricate formulae; at least, they are not so obtained by greenhouse specialists. In this calculation only the exposed glass surfaces and other exposed surfaces reduced to the

equivalent of glass surfaces are considered. The loss of heat by conduction through the glass is, of course, by far the greatest loss, but there is another considerable loss which it is very difficult, if not absolutely impossible to calculate, that is, the loss by air leakage between the lights of glass at the laps. These two make up practically all of the losses. The only other losses are those through open doors and through vents. The latter are generally intentional, and used to reduce the greenhouse to the required temperature; but a change of air is necessary for plant growth, so the vents are not opened except for reducing the inside temperature.

Modern greenhouses are glazed almost exclusively with double-thick glass in lights 16 in. wide and 24 in. long. The glazing bars, or ribs, are then usually 16½ in. center to center. The *lap* of the glass is ⅜ in. by eye measurement. Sometimes 24 x 24 in. glass is used, but not often, and with this size, the bow, or spring, of the glass when the wind blows is greater, and the heat loss through the laps may accordingly be greater as a consequence.

The cubic contents in ratio to the surrounding glass surface, the size and the shape are, of course, more or less factors, but as previously stated, only the glass and glass equivalent enter into the calculation for the quantities of radiating surface. The engineer may modify somewhat the quantities so obtained because of the ratio of the contents to the enclosing glass, or the size or shape of the structure, or because of its geographical position or its elevation, or because the greenhouse is in a particularly exposed position. The calculation is merely that of dividing the glass and the equivalent surface by the proper divisor; and where proper allowances are made for special conditions and where boilers are sufficiently large so that a liberal factor of safety or proper surplus is provided to cover these conditions over which the designer has no control, there is no better method known than the application of the table of divisors given in Table 52. The conditions for which the engineer must provide, and which are largely out of his control are as follows:

Workmanship in construction and glazing of glass house or houses; ratio of cubic contents enclosed to the glass surface; draft, if chimney is not designed by the engineer; fuel and its quality; firing habits of the operator, time of turning on steam and making up temperatures inside against falling temperature outside; attention to venting greenhouse heating coils—there is no one thing that the heating engineer can do which will so efficiently offset these negative factors, as the providing of a generous boiler power.

WATER TEMPERATURE

The average temperature of the water in a gravity hot water heating system is assumed to be about 150 deg. fahr. and the average co-efficient of transmission of the radiating surface (pipe surface) is assumed to be 2.

Pipe in different locations and banked pipes have different values, it is true; overhead mains, or pipes overhead free and unobstructed have the highest co-efficient, but because of their proximity to roof glass are not the best possible heaters; flat coils of parallel lines are more efficient than

wall coils, one pipe over the other; pipes pocketed under plant benches or in narrow walks against the sides of solid beds are less efficient than those in the open, but greenhouse heating engineers must deal with averages and the co-efficient 2 has been found to be safe.

Only the glass and other exposed surfaces reduced to the equivalent of glass are considered in the calculation. The factors or divisors for glass surfaces are derived from the following formula:

$$R = \frac{(T - t) \times G}{(150 - T) \times 2}$$

where

T = temperature desired, fahr.;
t = temperature out of doors (0 deg. fahr.);
150 = temperature of water in radiating surface, fahr.;
G = glass and glass equivalent surface;
2 = coefficient of transmission;
R = radiating surface.

From the above formula the divisors in the table following are derived:

TABLE 52. FACTORS FOR GLASS SURFACES

For 70 to 75 deg.	divide sq. ft. of glass and equivalent by 2.0
For 65 to 70 deg.	divide sq. ft. of glass and equivalent by 2.28
For 60 to 65 deg.	divide sq. ft. of glass and equivalent by 2.62
For 55 to 60 deg.	divide sq. ft. of glass and equivalent by 3.0
For 50 to 55 deg.	divide sq. ft. of glass and equivalent by 3.46
For 45 to 50 deg.	divide sq. ft. of glass and equivalent by 4.0
For 40 to 45 deg.	divide sq. ft. of glass and equivalent by 4.67
For 35 to 40 deg.	divide sq. ft. of glass and equivalent by 5.5

It will be noted that the temperatures given in the table are not 75 deg., 70 deg., 65 deg., etc., but 70-75 deg., 65-70 deg., 60-65 deg., etc. Greenhouses are so very sensitive to wind and so very unamenable to exact calculation that the initiated greenhouse man allows himself 5 deg. as leeway or as a factor of safety, and when he intends to heat to 60 deg. he specifies 55-60 deg.

Greenhouses do not respond exactly to figures in various ways: The same amount of glass may in two different houses enclose vastly different volumes; the air loss between the laps, though probably never calculated, may be quite different per square foot of glass in two houses of the same size, design and construction, on account of the difference in workmanship or of glass quality, or of both. 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, 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 15-20 deg. above zero, or even at 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.

A greenhouse that is not stocked, i.e., in which the crop is not planted and therefore not watered, and which does not carry the normal humidity is much more difficult to heat than a live house, one in operation. And so, the same formula will not work out exactly for outside temperatures below zero because of the varying heat loss. In some parts where the minimum outside temperature is above zero, or where the minimum of zero is rarely reached and then for short periods only, as in some Southern states, while it is true that the same amount of heat is required to offset the low outside temperature, the duration of the cold spell is so very short that it is unnecessary to pipe the houses or to provide boilers as large as the same house or houses would require further North so that the judgment and experience of the heating engineer is vital.

RATIO OF AIR CONTENT TO GLASS SURFACE

The ratio of air content of the greenhouses to the glass surfaces increases with the width, so the number of changes of air through laps of glass, however many they may be, are less per hour with a wide house than with a narrow one, and the experienced heating man knows this and judiciously omits a line or two of pipe in very wide houses, after having divided the glass surface by the proper divisor.

Fig. 39 shows in section two conventional, even span, adjacent greenhouses of the ridge and furrow, or saw-tooth type, converted by extending the roof lines until they bisect each other, into one even span house; and the sketch also shows at once that above the eaves line the cubic contents contained by the same amount of glass in the large house is just twice the quantity contained above the eaves lines in the two small ones, and, obviously, it requires less heat units to heat the one large house than it does the two small houses, although the glass surfaces are the same. But how much less heat? Who can say? Glass laid by eye measurement, and glass of varying quality are inconstants. How may the air loss be determined?

A table compiled for purposes of comparing the cubic contents and the glass surfaces in the roofs of the houses in widths of 20 to 80 ft. with the same roof pitch shows that the air content above the eaves line in the 20 ft. houses bears the following relation to the glass in the roof.

Glass : Contents :: 1 : 2.34

whereas in 80 ft. houses, with the same roof pitch:

Glass : Contents :: 1 : 9.8

KINDS OF PIPE

Greenhouse radiation is almost always made up of pipe surface—horizontal pipe placed on the side walls, on the sides of solid beds and under raised benches, sometimes on the columns supporting the roof.

For hot water heating in private greenhouses, 3½ in. cast iron pipe, in 9 ft. lengths, is best; this pipe is provided with a hub and a spigot; it

weighs about 11 lb. per line ft.. and holds 2 qt. of water per lineal foot; its superficial surface is about 1.05 sq. ft. to the lineal foot.

The two principal virtues of the 3½ in. cast iron pipe are that it is practically indestructible—it resists corrosion in the humid atmospheres of greenhouses much longer than any wrought pipe, and its large water content provides stability of temperatures, which is very desirable in private greenhouses, where the gardeners give no attention at all through the night to fires, or at most look after them only on especially cold nights.

Pipe of 2 in. diameter, both wrought iron and wrought steel, is used in small commercial houses where hot-water heating is suitable. The genuine wrought iron pipe costs considerably more than the steel pipe and hence is not used as frequently. Steel pipe as now manufactured is much more durable than formerly.

Pipe that is 1¼ in. in diameter is used almost exclusively for steam heating in whatever form. With hot-water heating, in order to provide even temperatures throughout the length of the greenhouse, it is desirable that the number of flow lines be equal to the number of return lines, consequently as much as possible the designer of the system always plans for coils of even numbers of lines which are usually placed under benches in two rows, the upper rows the flows and the lower the returns.

With steam heating, when overhead mains are used, coils may be considered as returns and it does not matter much whether there are an equal number or not. Mains and connections are designed so that the pressure drop will be low and with little loss of pressure there is very little difference in temperature end to end.

Gravity hot water coils constructed of 2 in. pipe are not practical in lengths of over 200 ft., indeed they are not really practical in lengths of over 150 ft., whereas steam coils or steam return lines are frequently installed 300 ft. in length.

Cast iron pipe of 3½ in. size is jointed by means of what are commonly called "rust joints;" the pipes are laid 6⅛ in. center to center; fittings are manufactured with hubs or bells and spigots; all are caulked together with rust joints.

Rust joints are not as well known or understood as they should be though they have been made for a century or more; the average fitter does not seem to take to the making of greenhouse rust joints and these mechanics seem bound to use salamoniac, salt or some such substance to set up rapid oxidation. These joints are properly made as follows:

Tarred rope cordage, or hemp is caulked into the hub or bell and then clean, moist iron borings are caulked on top of the rope foundation; the borings should be moist, just so that they will cake in the hand and should not be wet and they should be added a little at a time and caulked, not tamped; the more they are hammered, the better they are. They should be caulked sufficiently so that the finished joint will present a hard metallic surface.

Such joints properly made will permit turning on the water and operation of system immediately after the last joint is caulked and they

improve with age. Some old time steam heating systems are constructed with mains of cast iron pipe and caulked joints and the joints held against low pressure steam.

Besides the advantages of durability and of large water content, resulting in stability of temperatures, cast iron pipe is really desirable because it reduces labor costs, necessity for skilled labor and for cutting and threading tools—no tools are necessary, other than vise, pipe cutter, hammer, cold chisel and caulking tools. The use of vise and pipe cutter has only developed within recent years; formerly greenhouse pipefitters cut all pipe with cold chisels.

The making of a new connection or the repairing of a leak in a 3½ in. pipe line is much less serious an affair than the placing of tees in 3½ in. wrought pipe lines, pieces may be cut in and cut out and ends sleeved together easily and economically.

The 2 in. pipe is placed 4½ in. center to center and 1¼ in. pipe 3 in. center to center.

POSITION OF RADIATION

Greenhouses are piped in all sorts of ways to suit the great number of different ideas of greenhouse owners and operators; their different ideas on the subject of plant bench or plant bed arrangement which arrangements govern largely the location and arrangement of the piping; and to suit 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 is required to 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; however there is much latitude in the placing of pipe coils and it may be said that the greenhouse heating engineer does not always place piping, the radiating surface, just where it belongs, or just where he should place it, but rather he places it where he may, or the operator's planting arrangement permits.

As intimated, there are many problems of distribution of coils. When they must be large or long, and small or short coils served by the same mains, care must be taken to avoid short circuits through the short coils. Long pipe coils always present the problem of taking care of expansion.

The coils need not be graded very considerably in order to produce circulation; pitch, or grade, is required to produce high points in hot water heating where air may collect and be released and in steam systems for the purpose of drainage. Condensation should always flow with the steam current.

A grade, or pitch, of ⅜th of an inch in 10 ft. is ample in either case.

There is a dearth of dependable data and rules for the sizing of mains with which to connect the coils with the boiler or boilers, owing to the fact that greenhouse heating uses more pipe for radiating surface with less head or elevation than is required or used with any other type of gravity heating. Resistance through the heating unit is less, it is believed, in greenhouse heating than with any other unit; the frictional resistance through coils made up of two or more lines of steam piping 300 ft. long must be less than through a smiliar quantity of radiating surface in any other form.

Mains generally are planned for shortest distance between two points; there is a minimum of bends in greenhouse heating mains. For gravity hot water heating and for gravity steam heating in greenhouses it is believed that greater quantities of radiation are carried on mains than for any other purpose for the reason above given.

When it is found that the size of the system is so large as to call for large mains, say 7 in. pipe, or larger, it may generally be stated as a fact that the system is a little too large for gravity hot-water heating. Greenhouses should then be heated with steam, or at any rate the circulation should be accelerated by means of a centrifugal pump or hot-water circulator or accelerator, because large mains in gravity hot-water heating systems almost always present difficulties in the way of distinct self-contained circulations and counter currents.

For steam heating, 1¼-in. pipe is used almost exclusively, and the greenhouse man has found that where one line of 3½-in. pipe is required to produce a certain specified temperature with hot water as the heating medium, one line of 1¼-in. steam pipe at low pressure will do the same work. This fact is inconsistent with the application of the divisors given

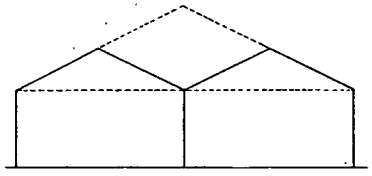


FIG. 39. SKETCH SHOWS RELATION OF CUBIC CONTENTS AND ROOF GLASS SURFACES.

for quantities of radiation, but the difference is probably accounted for by the fact that 1¼-in. pipe, being of so much higher temperature, is better distributed. Much of it is distributed in single lines; most of it in flat coils, and seldom in two rows, one over the other, and even then the coils are constructed so as to provide drainage, with a pitch from the supply end to the return bends at the opposite end, and back from the return bends to the return header, so that the coils converge and are not close

together. The pipe lines do not, therefore, interfere with each other in radiating their heat. Furthermore, with the proper boiler power it is easily possible to increase the pressure and consequently the temperature so that a greater range is possible than with hot water systems.

LARGE RANGES HAVE STEAM SYSTEMS

Hot-water heating was used almost exclusively 20 to 25 years ago. Now the use of hot-water heating is confined to private ranges and to small and medium-sized commercial ranges. It is practically never used in large commercial greenhouse ranges. Its cost would be prohibitive. Hot water is, of course, much more economical in small houses, but in large ranges a properly designed hot-water plant and a properly designed steam system would be equally economical, but the first cost of hot water is very much above the first cost of steam. In very large ranges vacuum steam heating is frequently used. This permits the use of smaller mains, smaller return connections and has the advantage of quick circulation, and immediately responds to sudden demands.

Overhead mains, generally speaking, are very desirable in a steam heating plant and not at all desirable in a hot water system; it should be understood that overhead mains are a little too near to the glass roof, that convection currents are almost entirely above the mains and not below, that most of the heat given off by these overhead pipes is lost through the glass.

A steam system, especially in long greenhouses, and commercial greenhouses are generally long, must be so fitted up as to provide for expansion, it must be flexible, and furthermore the clear space underneath plant benches, or the heights of solid beds, are such that there is insufficient room for running in converging coils; this makes overhead mains absolutely necessary in some cases and very desirable in others, but with hot water heating the runs of pipe are not so long and the temperature range is not so great, consequently there is not so much expansion to be provided for. There is not, therefore, the same necessity for overhead mains and furthermore, greenhouses that are heated with hot water, in which overhead mains are run to the far end and there deliver to floor coils, on walls under benches or in walks, which are in a sense return lines, are very unevenly heated as must be perfectly apparent.

In such systems the hottest water is of necessity in the overhead mains, the coldest water is necessarily too in the returns, the floor coils. The floor coils are naturally hottest at the far end of the greenhouse and they lose their heat in their progress towards the boiler. Furthermore, the far end of the house, the end at which the coils are fed by the overhead main, is the warmer end.

The coldest days, the zero days, especially in this part of the country, are few, indeed, probably in all six such days in the whole firing season. Most of the days of the firing season are mild and even in midwinter, during coldest weather, when the sun shines, there is very little need for heat and at such times, with overhead hot water mains, the small amount

of hot water made is overhead, where it is not required, and in order to heat the floor coils from end to end, and it is impossible to heat them evenly from end to end, a little larger fire must be maintained than would be necessary if the coils were in two rows, i.e., going and coming, flows and returns under the benches.

With gravity hot water heating, boilers should always be in pits. The use of overhead mains never makes up for lack of depth of boiler pit.

CHAPTER VI

WATER SUPPLY SYSTEMS AND PIPING

THE lack of data upon which to base water pipe sizes for plumbing fixtures, branches and mains is probably 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 53.

TABLE 53. 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.

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 lbs. per sq. in. per 100 ft. of pipe. The total pressure needed to discharge a given

Material for this section furnished for THE GUIDE by W. S. Timmis, consulting engineer, New York.

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 56, column 1, gives the vertical rise in feet to any fixture up to 150 ft. in height; column 2, gives the static head in lb. per sq. in. corresponding with the vertical rise.

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 53 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 53 and deduct 10 per cent for each floor above. This reduction in estimated amount is to take care of probable use. Thus, if 100 gallons are used on each floor of a 10-story building the size or pipe will be determined as in Table 54:

TABLE 54. 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 53, and for the main supply use 25 per cent of total of gallons used by fixtures and then take pipe size from Table 55 on a basis of 10 lb. pressure drop per 100 ft. or less if water supply pressure is less than 50 lb.

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 55 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. in height, a pressure drop of 52 lb. can be used on the lowest fixture branches; Table 53, 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 55 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 56), 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 55.

TABLE 54-A. 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 gals.	2 baths	24 gals.	3 baths	30 gals.
1 W. C.	8 gals.	2 W. C.	14 gals.	3 W. C.	18 gals.
1 sink	4 gals.	1 sink	4 gals.	1 sink	4 gals.
1 lav.	4 gals.	2 lavs.	6 gals.	3 lavs.	9 gals.
	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 gals.	1¼″	20 gals.	1¼″	24 gals.	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 54-A 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 54-A 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 54-A gives 2 in. for the first four floors with 1½ in. at fifth floor and 1¼ in. on the top floor.

TABLE 54-B. 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	
	Gals.	Main	Gals.	Main	Gals.	Main	Gals.	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.

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 54-B 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 54-B is 3½ in. main.

Note.—Table 54-B 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.

TABLE 55. 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 56. 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 LBS. 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 LBS. 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				

**Note.*—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 55, at the pressure drop indicated.

***Note.*—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 sq. in. with 100 gal. of water per minute required on each floor?

This is worked out in Table 54 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 55 and 56. On the top floor it will be necessary to use a 1½ in. branch to carry 60 gal. per min. 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 56 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 54 it is found that 240 gal. per min. will flow at the first floor, and assuming that this water supply is to be brought in a main 300 ft. long; Table 55 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 lbs. 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 = Cu. ft. per min. discharged
G = Gal. per min. 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 57, 58 and 59 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 min. 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 57. 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 58. 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 gallons per minute.

TABLE 59. 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 60 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 60. 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

CHAPTER VII

STEAM AND HOT WATER HEATING BOILERS

THE boiler is one of the most important parts of any heating system and its selection, as to type, size, rating, capacity, draft requirements, firing periods, kinds of fuel, principles of operation, efficiency and construction, should be made with great care.

TYPES OF BOILERS

Boilers used for heating, may be classified according to their construction as *Sectional*, either round cast-iron or rectangular cast-iron with horizontal or vertical sections respectively; *Fire Tube*, embracing steel firebox, or brick-set return tubular; and *Water Tube*, with either horizontal or vertical tubes and suitable drum arrangements. The most general use for heating falls in the first two of the three classifications given. For the small installations the round pattern cast-iron sectional boiler predominates, although certain designs of small steel boilers with fire-tubes and coil water tubes are also used to some extent. In the larger installations, the rectangular vertical section cast-iron boilers and the steel fire-tube boilers of the firebox pattern are used; the makes of either are numerous, and many detail differentiations in construction are to be noted.

For the small installations, it is customary to choose a design of boiler with such a disposition of flue passages as will give the maximum contact of flue gas with the indirect heating surface without unduly restricting the gas travel. For this the round sectional cast iron boilers are well fitted, and they are largely used for reason of their resistance to corrosion, pitting and other forms of deterioration. They are generally compact, requiring a minimum amount of floor space, low head room (low water line), and have a small water capacity.

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. Most sectional boilers are comparatively cheap in first cost but the labor of assembling is a factor which must be considered.

There are other forms of the boilers in the smaller sizes well adapted for heating small buildings, which embrace vertical section cast-iron construction, steel vertical tubular, and steel firebox construction, which have merit for particular classes of service. The features that are of

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greatest importance in such boilers are *grate area* sufficient to burn the particular fuel contemplated at a moderate rate when carrying the rated load, a depth of fire-pot sufficient to receive a liberal charge of fuel, an advantageous disposal of direct heating surface in the furnace for absorption of the radiant heat of the fire, sufficient indirect heating surface to extract the heat from the gases by convection, yet without interposing an undesirable resistance of flow to the chimney, and simple yet effective means for control of the draft and rate of combustion.

For the larger installations, such as large apartment buildings, hotels, office buildings, and other large public buildings, the fire-tube steel, the cast-iron vertical section and the water-tube steel boilers are commonly used, but with such a selection as the local conditions governing the installation may dictate. Some designs of the two former types are more compact than others and in such cases their size may influence their selection. Often low water line and low height may be a limiting consideration. In many cases also if steel tubular boilers are selected, the provision of sufficient room to permit of removing and replacing tubes may need to be considered. In this repect, the latter type is at a disadvantage compared with the sectional cast-iron and sectional steel types of boilers. The latter, due to their ease of access into crowded boiler rooms, are often given preference. Water-tube steel boilers are used mostly in the large installations where it is expected that there may sometime be a desire to turn to high pressure operation.

Fire tube boilers are usually constructed of steel, which shows the greatest resistance to splitting, cracking or similar stress due to the expansion and contractional strains of temperature differences of too excessive pressures, or temperature. They are well adapted to oil burning on account of this resistance to the wide temperature ranges encountered with this type of fuel. They have large water and steam spaces so that while they may heat up and steam slowly they retain heat and supply steam for comparatively long periods with a receding fire, thus tending to compensate for fluctuations in firing by the fly wheel effect of their water and steam capacities. Their large steam capacity also tends to prevent priming and fluctuation of the water line. They are comparatively steady under sudden and wide variations in load conditions and require little attention on this account. Steel boilers may be built for high or low pressure and are therefore flexible in converting from one pressure to another.

Fire tube boilers may be of the direct tube, return tube or a combination of direct and return tube type and have any desired ratio between grate and heating surface, are generally efficient in operation, and with adequate draft producing means may be operated up to 150 per cent of rating without difficulty.

Water tube boilers are usually constructed with steel or iron tubes, steel drums and either steel, cast steel or cast iron headers. On account of the smaller diameter of drums and the fact that the tubes are the only parts to come into direct contact with the hot furnace gases it is generally felt that this type of boiler is safer to operate, especially on high pressure. They heat up and steam rapidly but 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 fair.

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 the scale formation on the inside of a small tube may be comparatively rapid.

The water line is generally high and considerable space and head room is required. On account of being constructed with drums and banks of tubes they may be shipped knocked down and be assembled on the job, thus passing through small openings at any stage of the construction. The sectional construction facilitates repairs or increase and decrease in capacity. This type of boiler is efficient in operation, comparatively high in first cost, but may be operated to 200 per cent of the usual normal rating without undue loss in efficiency.

BOILER RATING

The three words, size, rating and capacity, when applied to a heating boiler are sometimes used indiscriminately to designate any one of the three things for which they should be used. The size of a boiler should indicate its physical dimensions, *i.e.* the size of a sectional boiler may be the inches in width of a rectangular fire box or the inches in the diameter of a round fire pot, combined with the number of sections; the size of a return tubular boiler is usually the inches in the diameter by the feet in the length of its shell combined with the number and size of tubes. The sizes of fire box boilers are usually arbitrary figures based on heating surface and grate surface. The size of a water tube boiler is generally stated in horse power, or the number of tubes wide by the number of tubes high with the size and length of tubes.

The rating of a boiler is the measure of what it will do under certain conditions. The manufacturers' rating is the measure which the manufacturers place upon the performance of their own boilers; this may be given for one or more well defined sorts of conditions or for what the manufacturers may choose to consider average working conditions without definition but in any case the conditions under which ratings have been established should be stated.

The ratings of low pressure boilers are usually stated in terms of the number of square feet of standard cast iron direct radiation the boiler will supply with steam or hot water, referred to conditions when the plant is heated up and operated under stable conditions with the radiation in still air at 70 deg. fahr. and all proper allowances made for the added load of piping and connections. These ratings are usually for an 8 hour or other stated firing period and for hard coal or other stated fuel with allowance factors for other lengths of firing periods and for other kinds of fuel when the smaller sized boilers are being considered. In connection with most rating the chimney or draft requirements corresponding to the ratings are given.

Unfortunately there are wide differences in the ratings of boilers by the various manufacturers due largely to the fact that there has never been a full and complete cooperation in the establishment of a standard code on which to rate. For the larger sizes of boilers and with other fuels,

particularly bituminous or soft coal, from 1 to 2 hour firing periods are generally considered.

In order to determine the effective rating of heating boilers, it is stipulated by the *Heating and Piping Contractors National Association* that the output shall be expressed in terms of square feet of direct radiation load (equivalent to 240 B.t.u. emission per square foot of steam radiation per hour, or 150 B.t.u. for water radiation), as follows:

$$\text{For steam boilers, output} = \frac{W \times H \times E}{240}$$

$$\text{For water boilers, output} = \frac{W \times H \times E}{150}$$

where

W = Average dry fuel burned per hour in lb. for period of test
H = Heat value per lb. of dry fuel in B.t.u.
E = Efficiency of boiler

SELECTION OF HEATING BOILERS

In selecting a boiler for any particular heating installation, there are several important requisites that should be met in order to make sure that the boiler is properly adapted to the conditions under which it will operate:

1. That the material and construction of the boiler be suitable for the service to which it is to be applied.
2. That the boiler be simple in construction, easily assembled, and easily operated.
3. That the boiler be so designed as to permit constant and thorough circulation so as to maintain a fairly even temperature in all parts.
4. That the steam liberating surface be of liberal area to allow for free disengagement of the steam.
5. That the water and steam spaces be properly proportioned so as to maintain even pressure and water line.
6. That the boiler be constructed in accordance with *A. S. M. E.* Boiler Code.
7. That the boiler have a liberal combustion chamber and flues so that combustion may be completed before the gases leave.
8. That all parts of the boiler be accessible for cleaning.
9. That the boiler be properly equipped with high grade gages, safety valves, and other fittings.
10. That draft requirements of the boiler for the conditions of the service be known and met.
11. That the variation in draft requirements under variations in load be given proper consideration.
12. That the capacity of the boiler be properly modified to suit the fuel used.
13. That the outlet openings on the boiler be of sufficient number and of ample size to allow for safe velocity of steam and to prevent carrying excess entrained water.
14. That the available data be sufficient to calculate the rate of combustion.
15. That the heating surface data and the relative proportions of direct and indirect surface are known and properly checked.

TERMINOLOGY

When any question arises concerning *size*, *rating* and *capacity*, it becomes particularly desirable that certain terms may be understood so that all data may be readily translated into comparable form. Among these are the following:

Rate of combustion is the amount of fuel in pounds burned per hour per square foot of grate surface.

Draft requirement, by which is meant the difference of pressure required to overcome the resistances to flow of gases through the fuel bed, flues, ashpit doors, smoke pipe, chimney, etc. This is expressed in inches of water. The data given by manufacturers generally covers the requirement of the boiler alone and does not include smoke pipe, chimney, etc., which should be added for according to conditions.

Heating surface, is any portion of the surface of the boiler which comes into direct contact with heated fuel, flame, or the gases of combustion.

Prime or direct heating surface, is that part of the total surface on which the fire shines or which comes into contact with heated fuel.

Secondary or indirect heating surface, is that part of the total surface which only comes into contact with the gases of combustion.

NUMBER OF UNITS

Reference has been made to the possibility of installing two or more boilers of proportionately less capacity in lieu of one sufficiently large to care for the whole load. Conditions often arise where the amount of installed load requires a draft with one boiler that calls for a height of stack that is not desirable from an artistic point of view. In such cases it is often better to install two or more boilers, instead of one, with especial regard to chimney conditions which will allow one boiler to be run at an overload at times and all boilers used only in the most extreme winter weather.

IMPORTANCE OF DRAFT

The capacity a boiler is capable of developing depends more upon the amount of draft available than upon any other factor. Assuming that a chimney is smoke tight and well built according to the Ordinance for Construction of Chimneys, 1921 (recommended by the *National Board of Fire Underwriters* and approved by the Society), the intensity of the draft depends upon the height of the chimney, and the quantity or amount of draft depends principally upon the effective area of the chimney.

Size of boiler plant is not the controlling factor of chimney height, but the desired rate of combustion is. There may be the same rate of burning in a small as in a large boiler so that the same height of chimney should be provided in one case as in the other, but the relative chimney areas will, of course, not be the same since that factor is dependent on the quantity of gas to be carried off. The mistake is not infrequently made of assuming that a low chimney will suffice for a small installation, and that a greater height would be needed for a larger plant, although it would be necessary to burn fuel at the same rate in either case.

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

is so small that the least unfavorable condition 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 head or force to offset unfavorable weather conditions, etc. Chimneys in this class produce about 0.009 in. draft per ft. of height in zero weather with 600 deg. in the stack according to the formula:

$$P = H\left(\frac{7.6}{T_o} - \frac{7.9}{T_s}\right)$$

where

P = draft pressure in inches of water.
H = height of chimney in feet.
T_o = absolute temperature of outside air.
T_s = absolute temperature of stack gases.

For low-pressure heating boilers, water heaters and warm air furnaces conservative modern practice in the matter of chimney sizes is in accordance with the accompanying schedule, Table 61:[1]

TABLE 61. CHIMNEY SIZES

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: Effective Area Sq. In.	Height in Ft. from Grate
790	590	973	8½x13	7x11½	81	70			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					10	79	
	900	1490	13x13	11¼x11¼	127	99			
	900	1490	8½x18	6¾x16¼	110	100			
	1100	1820					12	113	
	1700	2800	13x18	11¼x16¼	183	156			
	1940	3200					15	177	
	2130	3520	18x18	15¾x15¾	248	195			
	2480	4090	20x20	17¼x17¼	298	234			
	3150	5200					18	254	
	4300	7100					20	314	
	4600	7590	20x24	17x21	357	278			
	5000	8250	24x24	21x21	441				
	5570	9190		24x24*	576	380			
	5580	9200					22	380	
	6980	11500					24	452	
	7270	12000		24x28*	672	468			
	8700	14400		28x28*	784	531			
	9380	15500					27	573	
	10150	16750		30x30*	900	616			
	10470	17250		28x32*	896	635			
	11800	19500					30	707	
	14700	24300					33	855	
	17900	29500					36	1018	

*Dimensions below are for unlined rectangular flues.
[1]See also Code of Minimum Requirements for Heating and Ventilating of Buildings.

Chimneys recommended for larger boilers 15 to 250 hp. are proportioned in accordance with the report made by a joint Committee of the *American Boiler Manufacturers Association* and *Stoker Manufacturers Association* and approved by these organizations. The sizes are given in Table 62.

TABLE 62. HEIGHT OF STACK FOR AVERAGE INSTALLATIONS (Sea Level)

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%	Lbs. of Gas	85	77	73
CO_2	8%	9%	10%				

AVERAGE FRICTION LOSS 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

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. Cross sectional area should be 20 per cent larger than that of stack.

HEIGHT OF STACK IN FEET

For Sea Level and 60 deg. fahr. Outside Temperature and 0.1 in. Friction Loss per 100 ft.

TOTAL DRAFT REQUIRED IN. FOR FURNACE BOILER AND BREECHING	PER CENT OF BOILER RATING				
	100	150	200	250	300
0.3	56	.....	.....	.....	.....
0.4	74	69	.....	.....	.....
0.5	93	86	81	.....	.....
0.6	111	103	97	.....	.....
0.7	130	120	113	108	.....
0.8	148	138	129	123	.....
0.9	.....	155	145	139	132
1.0	.....	172	161	154	147
1.1	.....	190	177	170	162
1.2	.....	.....	194	185	176
1.3	.....	.....	209	200	191
1.4	.....	.....	226	216	206
1.5	.....	.....	.....	231	221
1.6	.....	.....	.....	.....	236
1.8	.....	.....	.....	.....	265
Assumed Flue Gas Temp.....	500	550	600	650	700

CORRECTION FOR ALTITUDE

HEIGHT ABOVE SEA LEVEL (FT.)	RATIO INCREASE IN DIAMETER	RATIO INCREASE IN HEIGHT
0	1.000	1.000
1,000	1.015	1.046
2,000	1.030	1.097
4,000	1.063	1.205
6,000	1.096	1.321
8,000	1.130	1.456
10,000	1.165	1.612

CHAPTER VIII

CODE FOR TESTING LOW-PRESSURE STEAM-HEATING BOILERS

REVISION OF 1923

(Adopted by AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS, Jan., 1924)

OBJECT OF THE CODE

THE object of the Code for Testing Low-Pressure Steam-Heating Boilers is to provide a standard method for conducting and reporting tests to determine the heat efficiency at various rates of steaming.

ESSENTIALS NECESSARY TO DETERMINE HEAT EFFICIENCY

The essentials necessary to determine the heat efficiency of a steam-heating boiler are:

a. The *total heat input.*
(The total heat input is the total heat value of the fuel charged.)

b. The total heat recovered at the boiler outlet.
(The total heat recovered at the boiler outlet is the total heat of the steam leaving the boiler less the total heat of the feed water entering the boiler.)

PREPARATIONS FOR TEST

The boiler shall be erected, covered and connected to conform to the directions and practice of the manufacturer. The piping shall be connected in such a way that the steam may be carried to a point away from the boiler and it shall be arranged so that the condensation cannot flow back to the boiler.

The moisture in the steam shall be determined by a steam separator, not less than 95 per cent efficient, placed in the steam delivery pipe as close to the boiler as possible. The piping between this separator and the boiler, also the separator itself, shall be thoroughly covered with insulating material. A pipe connected to the bottom of the steam separator shall be provided with a positive seal. The water shall be drained from the separator hourly and weighed immediately.

The steam connections between the boiler outlet and the separator shall be the same in size and arrangement as that to be used when the boiler is installed.

The water shall be fed to the boiler continuously from the feed tank through piping with all necessary valves, and all other water connections to the boiler shall be carefully blanked off. The temperature of the feed water shall be read from a thermometer inserted in a cup projecting well into the feed line near the boiler and filled with a heavy oil. All boiler water connections, including blow-off pipes, must be exposed to view, so that leakages may be observed, and either stopped or measured. The glands of the feed pump shall be carefully packed to prevent leakage.

Code prepared by Committee for Testing Low-Pressure Steam Heating Boilers: John Blizard, *Chairman*, Homer Addams, F. Paul Anderson, L. P. Breckenridge, P. J. Dougherty, L. A. Harding, F. B. Howell, and J. F. McIntire.

The boiler shall be connected with a short, direct smoke-pipe to a chimney flue of suitable size, height and construction to give proper draft.

The water spaces of the boiler shall be thoroughly boiled out with a solution of sal soda, potassium hydrate or sodium hydrate and then thoroughly rinsed with clean water.

The heating surface, firebox, ashpit, flues and chimney shall be clean and free from soot, ashes and dust at beginning of test.

APPARATUS AND INSTRUMENTS

Apparatus and instruments must be reliable and be arranged in such a way as to insure correct data.

Tanks for measuring the feed water may be calibrated with weighed quantities of water at the temperature to be used during the test, or mounted on accurate weighing scales. The water may be fed to the boiler by gravity, by air pressure or by feed pumps, from feed-water tanks supplied from the measuring tanks by gravity.

Accurate scales of suitable size shall be provided for weighing separator water, fuel and all refuse removed from the grate and ashpit.

Three draft gages shall be provided and so arranged as to determine the pressure difference at the level of inserting the pipe between the outside and the ashpit, between the outside and the firebox, and the outside and the smokehood. Draft measurements shall be made with draft gages reading to 0.01 in.

Accurately calibrated instruments shall be provided for measuring temperatures of gases, water and steam.

An Orsat apparatus shall be used for determining the flue gas composition. If recording carbon dioxide (CO_2) instruments are provided, they shall be checked every hour with the Orsat apparatus.

A Ringelmann chart shall be used for smoke observations.

Weather Bureau reports from the immediate vicinity may be used to determine the barometric pressure. When such reports are not available, a calibrated aneroid barometer or mercury column shall be used for determining the barometric pressure.

A calibrated steam gage or a mercury column shall be used for determining the steam pressure.

A log of the test shall be kept on record sheets similar to those provided by this Code.

DURATION OF TEST

The test shall continue for at least 16 hours if operated at the normal manufacturer's rating; if operated at other ratings it shall continue until as much fuel has been burned as would have been burned in a 16-hour test at normal rating.

METHOD OF STARTING AND STOPPING TEST

The New Fire Method of starting and stopping test may be used on any boiler when anthracite coal is used as fuel. All tests using other fuels shall be started and stopped by the Continuous Firing Method.

New Fire Method.—A preliminary fire shall be made and the boiler operated under test conditions for at least one hour before starting the test. The preliminary fire shall then be dumped, the ashpit thoroughly cleansed and dried wood placed on the grate and kindled. The test shall be considered started at the time of firing the charge of wood. On this charge of wood, fuel shall be placed. The wood shall be considered as having a heating value of 5000 B.t.u. per lb. The height of water line in gage glass and feed tank shall be noted and recorded at the time the preliminary fire is dumped. The water level in the boiler shall be kept at this level as nearly as possible throughout

the test and the water level in the boiler and feed tank must stand at this same height when the test closes. At the end of test the fire shall be dumped. The residual fire when dumped shall be placed in tightly covered cans, weighed and left to cool. After cooling it shall be forwarded for analysis and determination of its heat value and ash content. The total fuel fired shall be taken as the total weight of fuel exclusive of the wood used for kindling, to which shall be added the fuel equivalent of the wood and from which shall be subtracted the fuel equivalent of the residual fire. The weight of the ash content of the residual fire shall be added to the weight of ash and refuse removed from the ashpit and the sum recorded as ash and refuse removed from the ashpit.

Continuous Firing Method.—A preliminary fire shall be made and the boiler operated under test conditions for at least one firing period and not less than one hour before starting the test.

The fire shall then be burned low, thoroughly cleansed and the remaining live fuel spread evenly over the grate as the foundation for the first test fuel charge. The thickness of the fuel bed and the extent to which it has been burned through shall be quickly estimated or measured. The height of water line in gage glass and feed tank shall be noted and recorded. The test shall start at the time of making these observations. A weighed charge of fuel shall then be fired. The ashpit shall be thoroughly cleansed immediately and the test allowed to proceed.

A constant water level and rate of steaming shall be maintained throughout the test.

At the end of the test the fire should be burned low and cleansed so as to leave the same amount of live fuel on the grate as at the start. When this condition is reached and the water level in the boiler and feed tank are at the same height as at the start, record the time and this time shall be the time of stopping. The contents of the ashpit shall be removed promptly on stopping and placed in airtight cans, weighed and left to cool. The boiler shall be charged with all fuel charged during test.

METHOD OF FIRING

The method and frequency of firing shall be as agreed upon by the manufacturer and purchaser.

FUEL SAMPLING

During the progress of the test, fair samples at regular intervals shall be taken with a shovel from the fuel charge, stored in a covered vessel in a cool place, and after crushing and quartering, two one-pint glass jars or other airtight vessels shall be filled. The gross sample for slack coal and small sizes of anthracite in which the impurities do not exist in abnormal quantities or in pieces larger than ¾ in., should weigh approximately 500 lb. and not less than 1000 lb. for other solid fuels.[1]

The small samples shall be preserved for determinations of the proximate analysis, ultimate analysis and calorific value.

The refuse taken from the ashpit and grate shall be reduced by crushing and quartering to a quantity sufficient to fill two one-pint jars or other airtight vessels for determining its combustible content in the laboratory. Care must be taken to crush and quarter the coal, ash, and refuse on a clean floor; to avoid contaminating the sample a metal plate is to be preferred to a concrete floor. Care must be taken to see that the ash and refuse does not burn after removal from the grate or ashpit.

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[1] As recommended by the *American Society for Testing Materials*, D21—16, p. 756, 1921.

The Committee on Code for Testing Low-Pressure Heating Boilers of the AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS is prepared to interpret the meaning of any items on the Code.

It is requested that all tests be filed with the AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS.

STANDARD FORM

For Reporting Results of Low-Pressure Steam-Heating Boiler Tests

RESULTS

Of a Test on a Low-Pressure Boiler

DATE OF TEST .....
CONDUCTED AT .....
DIRECTOR OF TEST .....(signature)
MANUFACTURER OF BOILER .....
OWNER OF BOILER .....
SIZE OF BOILER .....
TYPE OF BOILER .....

GENERAL PARTICULARS OF BOILER AND FUEL

BOILER

Type .....
Made by .....
Length of Grate (or Diameter) .....in.
Width of Grate .....in.
Fuel Capacity (Greatest Possible Volume) .....cu. ft.
Maximum Fuel Depth (Greatest Possible Depth of Fuel) .....in.
Fuel Capacity Normal .....cu. ft.
Fuel Depth Normal .....in.
Average Distance from Top of Normal Fuel Charge to Crown Sheet .....in.
Total Furnace Volume, Grate to Crown Sheet and Bridge Wall .....cu. ft.
Total Combustion Space Beyond Bridge Wall .....cu. ft.
Water Capacity (To Water Line) .....lb.
Height of Water Line .....in.
Steam Connections Used {Number .....
{Size .....in.
Kind of Insulation .....
Thickness of Insulation .....in.
Detailed Description of Boiler .....

SMOKE PIPE AND CHIMNEY

Area of Smoke Pipe .....sq. in.
Length of Smoke Pipe (Boiler to Chimney) .....in.
Number and Kind of Bends in Smoke Pipe .....
Chimney, Height above Grate .....ft.
Chimney, Area at Bottom .....sq. ft.
Chimney, Area at Top .....sq. ft.

FUEL

Name .....
Size .....

PROXIMATE ANALYSIS		As Fired	Moisture Free
Moisture	per cent		
Volatile Matter	per cent		
Fixed Carbon	per cent		
Ash	per cent		

ULTIMATE ANALYSIS		As Fired	Moisture Free
Carbon	per cent		
Hydrogen	per cent		
Oxygen	per cent		
Nitrogen	per cent		
Sulphur	per cent		
Ash	per cent		

These forms may be obtained on request at the office of the Secretary of the AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS, 29 West 39th Street, New York City, at nominal cost.

HEAT VALUE (GROSS)

B.t.u. per lb. as fired .....
B.t.u. per lb. moisture free .....
B.t.u. per lb. moisture and ash free .....

CHARACTER OF FUEL

(State whether coking or free-burning, clinker troubles, etc.)

METHOD OF FIRING

PRINCIPAL RESULTS OF TEST

Heat recovered at the boiler outlet per hour .....1000 B.t.u.
Maker's rating (sq. ft. radiation × 240) .....1000 B.t.u. per hr.
Percentage of maker's rating developed .....per cent
Mean interval between charging fuel .....hours
Mean interval between attention of any kind to the fire, including charging .....hours
Overall thermal efficiency .....per cent

DETAILED RESULTS OF TEST

(For full particulars of boiler and fuel see "general particulars" ante)

GENERAL INFORMATION

1. Date of Test .....
2. Number of Test .....
3. Location of Boiler .....
4. Maker of Boiler and Type .....
5. Owner of Plant .....
6. Test Conducted by .....
7. Duration of Test .....hr.
8. Manufacturer's Rating of Boiler .....sq. ft. radiation[1]
9. Grate Area[2] .....sq. ft.
10. Barometric Pressure .....in. of mercury

FUEL

11. Heat value, as fired .....B.t.u. per lb.
12. Number of Times Fuel Charged during Test .....
13. Intervals between Charging, hrs. Longest.....Shortest.....Average.....
14. Intervals between Attention of any Kind to the Fire, including firing, hr. Longest.....Shortest.....Average.....
15. Average Fired per Charge[3] .....lb.
16. Depth on Grate at Start of Test (After Firing) .....in.
17. Depth on Grate at Finish of Test .....in.
18. Weight as Fired during Test[3] .....lb.
19. Weight as Fired per Hour[3] .....lb.
20. Moisture in Fuel .....per cent
21. Weight Fired per Hour less Moisture:[3]

$$\frac{100 - \text{item } 20}{100} \times \text{item } 19 \text{ .....lb.}$$

ASH AND REFUSE

22. Weight of Ash and Refuse Removed from Grate .....lb.
23. Weight of Ash and Refuse Removed from Ashpit .....lb.
24. Total Weight of Ash and Refuse Removed[4] (item 22 + item 23) .....lb.

[1] One sq. ft. radiation to be assumed equal to 240 B.t.u. per hr.
[2] If the grate have an unusual shape, method of computing area must be stated under "Remarks."
[3] When the New Fire Method is used the equivalent fuel charged shall be given throughout. The method of obtaining this is shown at the end of this table.
[4] To include ash content of residual fire when New Fire Method is used.

25. Total Ash and Refuse, Percentage of Fuel as Fired.....
26. Combustible in Ash and Refuse.....per cent

TEMPERATURE

27. Steam.....deg. fahr.
28. Feed Water.....deg. fahr.
29. Gases Leaving Boiler.....deg. fahr.
30. Boiler Room.....deg. fahr.
31. Outside Air.....deg. fahr.

DRAFT INTENSITY

32. In Smokehood.....in. water
33. Over Fire.....in. water
34. In Ashpit.....in. water

OUTPUT

35. Equivalent evaporation from and at 212 deg. fahr. per hr. of test.....lb.
36. Equivalent evaporation from and at 212 deg. fahr. per lb. of dry coal fired.....lb.
37. Heat Recovered at the Outlet per hour (item 35 × 0.97).....1000 B.t.u.

STEAM AND WATER

38. Steam pressure (gage).....lb. per sq. in.
39. Total Water Fed to Boiler during Test.....lb.
40. Priming: Total Water Removed from Separator, Per Cent of Total Feed Water.....per cent

HEAT BALANCE

		Per lb. fuel as fired	Per cent heat in fuel fired
41.[5]	Heat to steam leaving outlet (and thermal efficiency boiler, furnace and grate)		
42.	Heat lost by hot flue gases, exclusive of steam		
43.	Heat lost by not burning carbon monoxide		
44.	Heat lost by steam in flue gas		
45.	Heat lost by combustible in ash and refuse		
46.	Heat lost by radiation		
47.	Undetermined losses and errors		
48.	Total, items 41, 42, 43, 44, 45, 46, 47 and calorific value of dry fuel		100

Additional items, for use only with New Fire Method of starting

FUEL USED

49. Weight of wood for kindling.....lb.
50. Heat value of wood.....B.t.u. per lb.
51. Weight of residual fire.....lb.
52. Heat value of residual fire.....B.t.u. per lb.
53. Fuel value of wood $\left(\text{item } 49 \times \frac{\text{item } 50}{\text{item } 11}\right)$.....lb.
54. Total fuel fired during test (exclusive of wood).....lb.
55. Total equivalent fuel charged during test (item 53 + item 54).....lb.
56. Fuel value of residual fire $\left(\text{item } 51 \times \frac{\text{item } 52}{\text{item } 11}\right)$.....lb.
57. Equivalent fuel used during test (item 55 − item 56, this value to be used for item 18).....lb.

ASH AND REFUSE

58. Ash in residual fire (by analysis).....per cent
59. Total ash content of residual fire:

$\left(\text{item } 51 \times \frac{\text{item } 58}{100}\right)$.....lb.

[5]Item 41. Heat to "steam," includes the heat used to raise the water removed from the separator from the feed water temperature to the steam temperature.

60. Total ash and refuse removed from ashpit.....lb.
61. Equivalent ash and refuse removed from ashpit (item 59 + item 60, this is the value to be used for item 23).....lb.

LOG SHEET NO. 1

GENERAL SHEET

Test of.....boiler with.....coal

Date.....Test No.....

Time | General Notes

(Here will be recorded the method and times of starting and stopping, the method of firing, the difficulties encountered with ash and clinker, the times of cleaning, slicing and raking the fire, the caking and other properties of the coal, the manipulation of the dampers, etc.)

LOG SHEET NO. 2

Date..... Test No.....

FUEL, ASH AND REFUSE

Detailed Record of Coal Fired During Test

TIME OF FIRING	QUANTITY FIRED, LB.		NET	FIRED IN INTERVAL, LB.	TOTAL FIRED, LB.
	Tare	Gross			

Detailed Record of Ash and Refuse Removed

TIME OF REMOVAL	QUANTITY REMOVED FROM GRATE			QUANTITY REMOVED FROM ASHPIT		
	Tare	Gross	Net	Tare	Gross	Net

Special observations for New Fire Method of starting:

Weight of wood used for kindling.....lb.
Weight of fire dumped at end.....lb.

LOG SHEET NO. 3

Date..... Test No.....

Observations of Feed Water, Pressures, and Temperatures

TIME	FEED WATER, LB.			SEPARATOR WATER, LB.			BOILER PRESSURE LB. PER SQ. IN.
	Gross	Tare	Net	Gross	Tare	Net	

DRAFT, IN.—WATER			BOILER ROOM TEMP. DEG. FAHR.	FEED WATER TEMP. DEG. FAHR.	FLUE GAS TEMP. DEG. FAHR.
Below Grate	Above Grate	At Smokehood			

Boiler gage correction
Thermometer corrections
Barometer: At start At finish
Correction not allowed for on sheet

LOG SHEET NO. 4

Date..... Test No.....

Detailed Record of Gas Analysis

TIME	CO_2	$CO_2 + O_2$	O_2	$CO_2 + O_2 + CO$	CO	N	REMARKS

LOG SHEET NO. 5

Date..... Test No.....

Smoke Readings

No.	TIME	RINGELMANN CHART	No.	TIME	RINGELMANN CHART	REMARKS

CHAPTER IX

PUMPS FOR HEATING AND VENTILATING EQUIPMENT

INTRODUCTION

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.

In applying pumps to heating and ventilating systems the following points should be considered:

For Boiler Feed Pumps—the load factor, temperature of the intake water, static head on the pump intake, total pressure against which the pump must discharge, steam pressure available for steam driven pumps, provisions for emergency and breakdown service, method of control; as to whether pumps should be steam, electric or power driven, depending upon the relative first costs and economies taking into consideration the possibilities of the use of the exhaust from steam driven pumps and any difference in the cost of labor and attention required.

For Condensation Return and Vacuum Pumps—method and efficiency of return trapping, degree of tightness of the system, temperature of the condensate at the pump, probable cooling effect of the return piping, lifts (if any) required in the system, length of run of piping from farthest radiator to the pump, the total pressure against which the pump must discharge the total load to be carried, the load factor, the vacuum (if any) to be carried, as to whether the pump is to be automatically controlled from the water-line in a condensate receiver from the vacuum, or from both, the static heads on the suction and discharge, provisions for emergency and breakdown service and as to whether the pump is to be steam, electric or power driven, etc., as above.

For all other Pumps—the service to be performed, loads and load factors, emergency and breakdown service, methods of driving and methods of control.

Standards for Condensation to be Handled—The quantities of condensate

Material for this section prepared for THE GUIDE by Perry West, consulting engineer, Newark, N. J.

to be handled from direct radiation, 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 $W = \frac{Q \times 60 \times T}{55.6 \times H}$

where

W = lbs. of condensate per hour, R = sq. ft. of radiation, Q = cu. ft. of air per min., T = temperature rise of air in deg. fahr. and H = the latent heat of steam in the system in B.t.u. per pound.

The normal capacity of pumps to be based on condensate at a temperature of not over 180 deg. fahr. For temperature of condensate above 180 deg. fahr. capacity should be increased above that estimated for 180 deg. fahr. condensate as per the following Table 63.

TABLE 63. TEMPERATURE OF CONDENSATE AT PUMP SUCTION

Deg. fahr.	Factor
190	1.15
200	1.56
204	2.00

To use Table 63, 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.

The above increase in pump capacity may be reduced by providing a static head above the pump suction and when this static head is made equivalent to 15 ft. minus the absolute boiling pressure of the condensate (measured in feet of water) no increase is necessary.

Allow sufficient head in addition to the total head necessary to overcome static head, velocity head, pipe friction and boiler pressure, wherever condensate is to be returned direct to a boiler from the pump.

BOILER FEED PUMPS

Types.—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 pumps.

Capacities.—The capacity of a boiler feed pump should be based on 34.5 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 2 for intermittently operating pumps and a factor of safety allowance of 1½ for continuous operating pumps, to provide for unusual demands when the water in boilers becomes low or excessive loads are carried.

Piston Speeds in Feet per Minute.—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

TABLE 64. 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 65. 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 66. 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	4.60	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

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

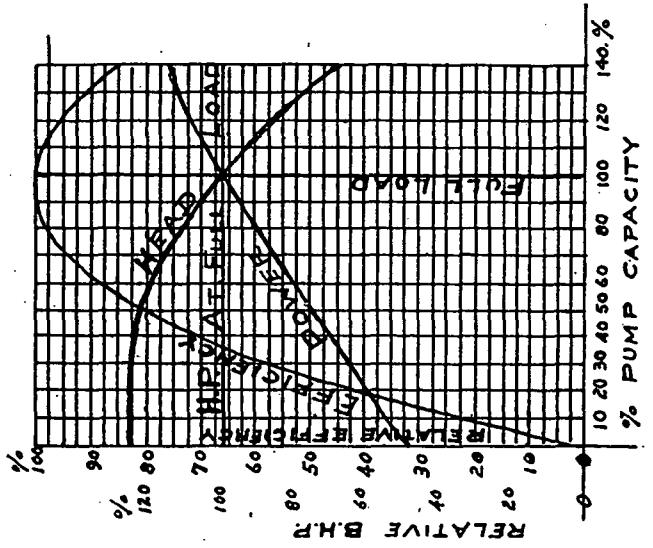


FIG. 41. FOR SELECTION OF SIZE AND STAGE OF CENTRIFUGAL BOILER FEED PUMPS

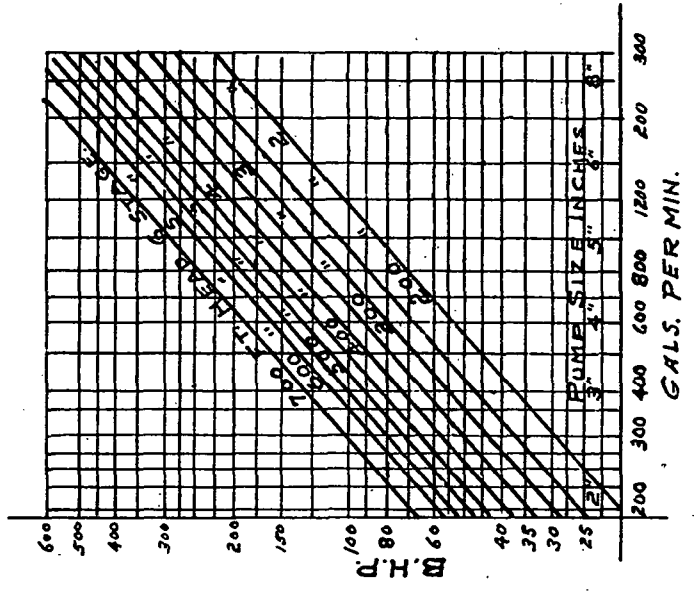


FIG. 40. TYPICAL CHARACTERISTICS OF CENTRIFUGAL BOILER FEED PUMPS

usually employed for installations of less than 1000 boiler horsepower. Screw pumps may be used with good economy for small capacities.

TABLE 67. SCREW PUMPS

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 per cent to 70 per cent.

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

TABLE 68. 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	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	.....	2½	2	100	1450
2½	.....	3	2½	150	2175
3	.....	4	3	225	3262
4	.....	5	4	400	5800
5	.....	6	5	620	8990
6	.....	8	6	900	13,000
8	.....	10	8	1600	23,000
Three Stage for 150 lb. Working Pressure					
2	.....	2½	2	100	1450
2½	.....	3	2½	150	2175
3	.....	4	3	225	3262
4	.....	5	4	400	5800
5	.....	6	5	620	8990
6	.....	8	6	900	13,000
8	.....	10	8	1600	23,000
Four Stage for 250 lb. Working Pressure					
2	.....	2½	2	100	1450
2½	.....	3	2½	150	2175
3	.....	4	3	225	3262
4	.....	5	4	400	5800
5	.....	6	5	620	8990
6	.....	8	6	900	13,000
8	.....	10	8	1600	23,000

CONDENSATION RETURN PUMPS

Condensation return pumps may be of the following types:

a. Automatic pumps and receivers
b. Continuous operation non-automatic return pumps

Volumetric Capacities of Receivers.—To be not less than 3 times the maximum minute volumetric flow of condensation to be handled, measured between the high and low water lines in the receiver.

Piston Speeds in Feet per Minute.—Not more than 10 times the square root of the number of inches in the length of stroke.

The ratio between the pump displacement and the maximum volumetric rate of the flow of condensate to be handled shall be not less than 3.0 for automatic pumps and receivers and 2.0 for non-automatic return pumps.

Normal Capacities for Centrifugal Pumps.—Not less than 2 times the maximum rate of flow of the condensation to be handled.

TABLE 69. 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 70. CENTRIFUGAL RETURN PUMPS WITH RECEIVERS

SIZE OF PUMP DISCHARGE INCHES	RECEIVER CAPACITY GALLONS	SQ. FT. DIRECT RADIATION	LBS. 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

TABLE 71. CHARACTERISTICS OF CENTRIFUGAL 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

RETURN LINE VACUUM HEATING PUMPS

These may be of the following types:

a. Direct acting reciprocating steam driven return line vacuum pumps
b. Reciprocating power driven return line vacuum pumps
c. Motor driven return line vacuum pumps

High pressure traps should never discharge directly into a vacuum return. An excessive amount of vapor will form due to re-evaporation of a considerable part of the hot condensation. This may cause a very material reduction in the vacuum maintained by the pump. Fig. 42 shows a method of disposing of the greater part of the vapor of re-evaporation and at the same time lowering the temperature of the condensate.

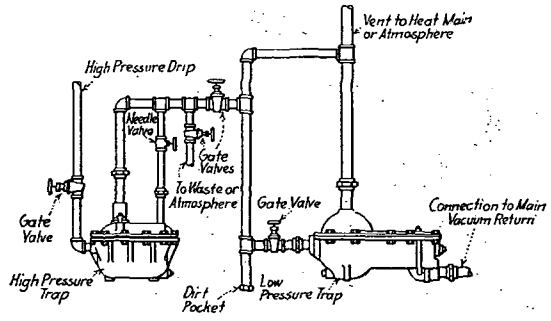


FIG. 42. METHOD OF DISCHARGING HIGH-PRESSURE APPARATUS INTO LOW-PRESSURE HEATING MAINS AND VACUUM RETURN MAINS THROUGH A LOW-PRESSURE TRAP

DISPOSAL OF VACUUM PUMP DISCHARGE

The discharge from reciprocating vacuum pumps of either the steam or power driven type is a mixture of water and air. Means must be provided for releasing the entrained air. This requires water surface area in either a tank having a large horizontal cross section or a stand pipe of enough 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 allow one square foot of horizontal cross-section for each 2100 lb. of water per hour. A stand pipe with diameter equal to that of the pump cylinder is usually sufficient.

Wherever a suitable location may be obtained the freely vented air

separating tank is generally used. The tank must be located high enough so that the pressure produced by the water column in the discharge pipe will be sufficient to overcome that in the low-pressure boiler feed water heater or other point of disposal. Fig. 43 shows the proper arrangement of vacuum pump, air separating tank and feed water heater.

The air escapes through a vent in the top of the tank and the water flows by gravity to the feed water heater through the loop seal attached to the discharge outlet in the tank. If the rate of flow of returns to the tank exceeds the rate of discharge from the tank the excess overflows through an opening on the end near the top.

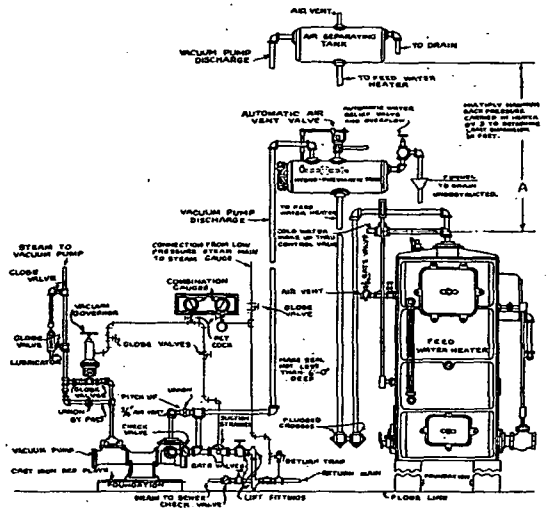


FIG. 43. METHOD OF CONNECTING VACUUM PUMP, FEED WATER HEATER AND SINGLE CONTROL HYDRO-PNEUMATIC TANK OR AIR SEPARATING TANK

Where 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, the hydro-pneumatic tank is used. A float controlled valve is placed on the air outlet of the separating tank and so arranged that when the water of condensation has not sufficient head to flow by gravity to the point of use, the air will be confined in the upper part of the tank. As the pump continues to deliver water and air to the tank the pressure within the tank increases until 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 air pressure plus the column of mixed air and water in the pump discharge to the tank is the total head against which the pump must act. Fig. 43 shows a hydro-pneumatic tank, Figs. 44, 45 and 46 show vacuum pump connections for several different conditions of service.

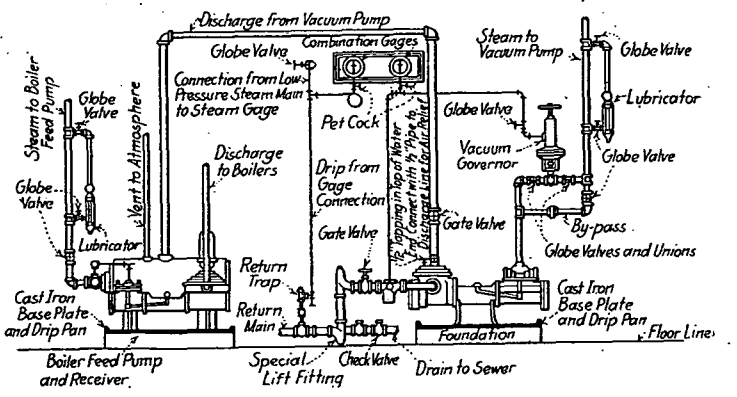


FIG. 44. METHOD OF CONNECTING VACUUM PUMP AND AUTOMATIC BOILER-FEED PUMP AND RECEIVER

Table 72 gives the sizes of plain or 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.

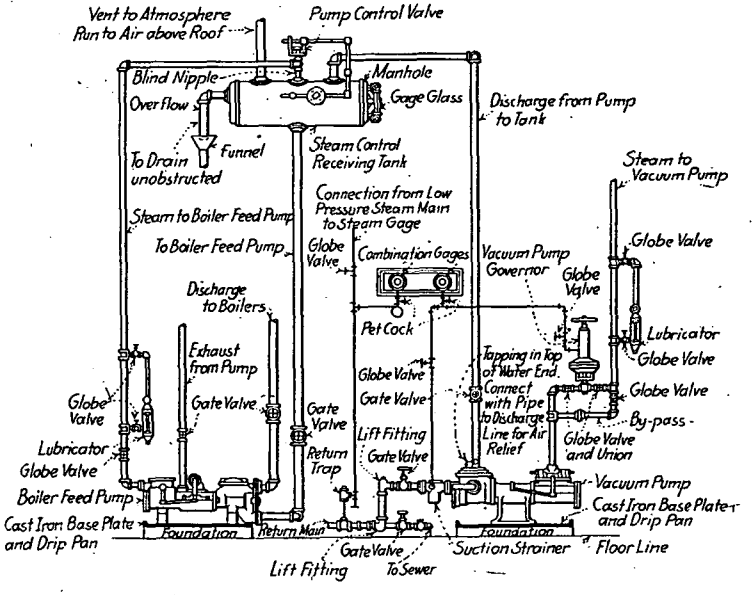


FIG. 45. METHOD OF CONNECTING VACUUM PUMP, BOILER-FEED PUMP AND STEAM-CONTROL RECEIVING TANK

TABLE 72. SIZE OF PLAIN AND HYDRO-PNEUMATIC TANKS

COMPENSATION LB. PER HR.	SIZES OF PLAIN AND HYDRO-PNEUMATIC TANKS			
	FOR AIR SEPARATOR ONLY		FOR AIR SEPARATOR AND WATER STORAGE	
	Diameter In.	Length In.	Diameter In.	Length In.
4000	12	24	24	36
6000	12	36	24	48
8000	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

LIFT FITTINGS

Lift fittings are special devices used in pairs at points in a vacuum heating system where condensation is to be lifted to a higher level. The condensation is lifted in "slugs" on the air lift principles: the slugs being obtained by the use of a comparatively small diameter vertical return with its lower end submerged in the well below the level of the horizontal return which it drains. The lower lift fitting allows the condensation to accumulate in the well below the inlet connection until it seals the vertical passage, thus causing a slight reduction of the vacuum on the inlet side and forcing the water from the well through the vertical lift pipe to the higher level. The upper lift fitting allows the condensation to flow into the horizontal return without falling back into the lifting line.

Lifts of 6 ft. or over should be made in steps rather than all in one rise. Steps should be used instead of "Drag" lifts through long upwardly inclined pipes. In any case the pipes between the lifts must grade downward toward the pump.

When these fittings are required, the usual places to install them, is with a suction strainer at the pump, and when step-ups occur, in the return line.

STEAM DRIVEN RECIPROCATING RETURN LINE VACUUM PUMPS

Volumetric displacement of the water cylinders should be 8 to 10 times the volumetric rate of flow of the condensate to be handled.

Piston Speeds.—Not more than 20 times the square root of the number of inches in the length of stroke.

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.

TABLE 73. 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

The capacities given in Table 73 are for pumps having water cylinder with the length of stroke equal to the diameter of the water piston.

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.

Proportioning of Steam End of Reciprocating Vacuum Pumps

In proportioning the steam cylinder of the pump the following formula will give results which are safe to use.

$$A_s \times \frac{P_b}{3} = A_w \times \left(\frac{V}{2} + P_d\right)$$

From which we have

$$A_s = \frac{A_w \times \left(\frac{V}{2} + P_d\right) \times 3}{P_b}$$

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 sq .in.)

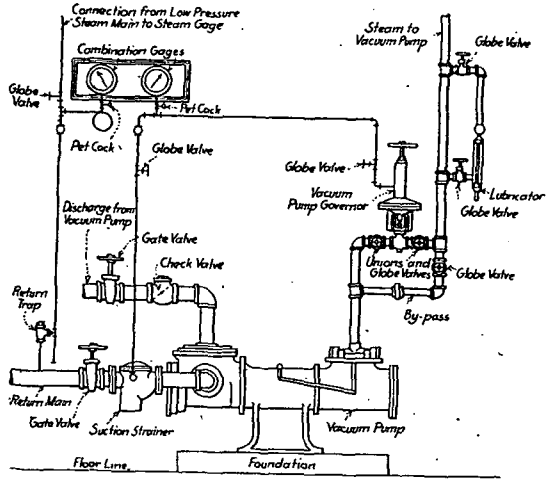


FIG. 46. METHOD OF MAKING CONNECTION TO STEAM-OPERATED VACUUM PUMP

In no case should the head against the discharge of reciprocating pumps exceed 15 lb. unless the pump stroke exceeds the bore and thus reduces the bad effect of clearance.

Where the pressure on the heater, boiler, etc., varies materially from time to time but in general is near the minimum, a substantial saving in energy may be obtained by using a hydro-pneumatic tank instead of a plain tank set at a higher elevation to overcome the peak pressure in the boiler or heater. The use of a plain tank keeps the pump operating against the maximum head, where the hydro-pneumatic tank set lower operates as a plain tank whenever the gravity head in the tank is sufficient to cause flow from its elevation, and employs the combination of air pressure and gravity head, with air vent closed, only at times of peak load. Only then is the air pressure load added to the pump discharge.

Where the head on the delivery side of steam driven pumps exceeds 15 lb. it is good practice to deliver the condensation 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 controlled by a throttle valve, actuated by the water line in the receiving tank.

MOTOR DRIVEN RETURN LINE VACUUM PUMPS

Reciprocating Vacuum Pumps.—The displacement and piston speeds should be the same as for the water end of reciprocating steam driven return line vacuum heating pumps.

The type of drive between motor and pump may be chain, gear or belt.

Other than Reciprocating Pumps.—May be of the centrifugal or rotary type with receivers and generally of one of the following arrangements.

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 receiving tank capacity should be stated in gallons, and in case of automatically controlled units should be the capacity of the tank in gallons between the high and low water levels in this tank, as determined by the water-line control.

The receiving tank may be placed either on the suction side or on the discharge side of the pump. When placed on the suction side of the pump the capacity of the tank may be used to retain the condensation and to take care of the fluctuations between the rate of condensate returned and the rate of the pump delivery.

The suggested receiving tank capacities (as previously defined) for continuously operated and for automatically controlled units should be as follows:

TABLE 74. RECEIVER TANK CAPACITIES

Sq. Ft. Equivalent Direct Cast Iron Radiation Surface	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

The air capacities recommended, referred to cubic feet of air per 1000 sq. ft. of equivalent cast iron direct radiation, may be assumed on a decreasing ratio as the system increases in capacity of equivalent square feet of radiation, in accordance with the following Table 75. It should be noted that while water capacities of pumps to be added for fan blast

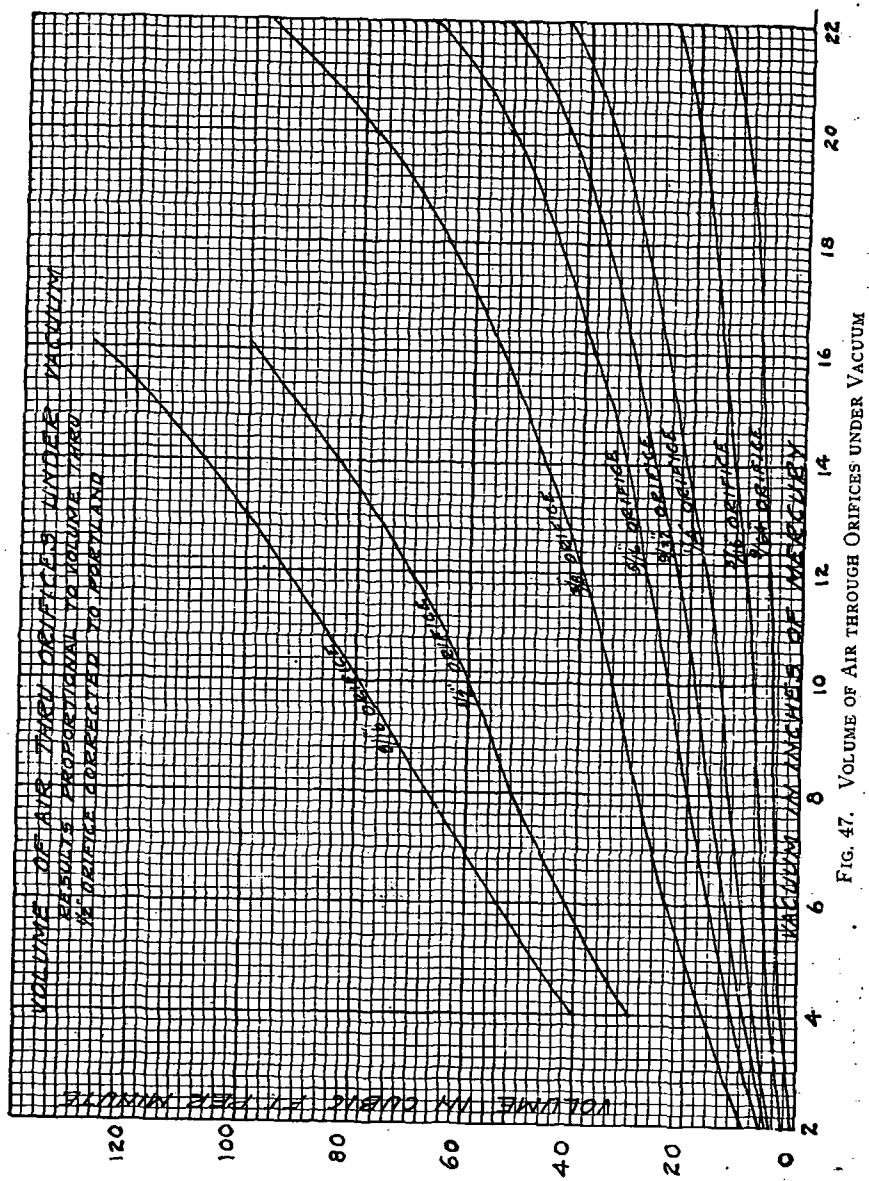


FIG. 47. VOLUME OF AIR THROUGH ORIFICES UNDER VACUUM

heaters are to be based upon their equivalent in direct radiation the air capacities for this class of radiation may be the same as for direct radiation.

TABLE 75. AIR CAPACITIES

SQ. FT. DIRECT EQUIVALENT RADIATION SURFACE	DIAMETER ORIFICE VAC. 10"	AIR CAPACITY CU. FT. PER MIN.
8,000	$\frac{9}{64}$"	5
16,000	$\frac{3}{16}$"	9
26,000	$\frac{1}{4}$"	15
40,000	$\frac{9}{32}$"	19
65,000	$\frac{3}{8}$"	34
100,000	$\frac{1}{2}$"	60
150,000	$\frac{9}{16}$"	80
250,000	Three $\frac{1}{2}$"	180

The air capacity of the pump should be measured at a point in the main vacuum return line just ahead of the vacuum strainer when the pump is operating under the vacuum specified at the pump suction and when handling the quantity of condensate specified at a temperature not exceeding 180 deg. fahr.

Air test may be made with water at lower temperatures. This determination should be made by means of a standard test orifice located in an inlet connection to the pump suction and consisting of a plate $\frac{1}{8}$ of an inch thick with a reamed hole having sharp edges and of a diameter corresponding to the capacity of the pump.

The accompanying Fig. 47 may be used to give the quantity of air handled, corresponding to several sizes of orifices and different degrees of vacuum met with in practice.

The water capacity of the pump when operating against 8 in. of mercury vacuum should be not less than three-tenths (0.3) of a pound of water per hour per square foot of equivalent cast iron direct radiation based upon condensation 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.

Commercial pumps are built for 10, 20, 30 and 40 lb. gage pressure at the water discharge of the pump.

TABLE 76. SIZES, SPEEDS, HORSE POWERS AND CAPACITIES MOTOR DRIVEN CONDENSATION RETURN PUMPS

Rating in Sq. Ft.	0 to 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	$\frac{3}{8}$	$\frac{3}{4}$	$\frac{3}{8}$	$\frac{3}{4}$	$\frac{3}{8}$	$\frac{3}{4}$	$\frac{3}{8}$	$\frac{3}{4}$
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

No additional allowance need be made for covered mains or risers, but exposed mains or risers used as heating surfaces should be included in calculating the equivalent square feet of direct radiation.

PUMP SPECIFICATIONS

Reciprocating and power driven pumps should be specified as to make, size, water and steam working pressures, piston speed, temperature of water to be handled, electric motor characteristics and the trade standard, required in accordance with the manufacturers' adoptions, copy of which is appended to this section of the code for reference.

TABLE 77. 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					

The kind of drive should be specified for power driven pumps.

Centrifugal and Rotary pumps should be specified as to make, type, capacity temperature of water to be handled, speed and motor characteristics including:

1. Name of motor manufacturer
2. Manufacturers rated Horse Power
3. The maximum temperature rise for any part of the motor above the temperature of the surrounding air
4. Full Speed in R. P. M.
5. Current characteristics
6. Whether the motor is open, semi-enclosed or fully enclosed.

The following should also be included in the specifications, total head to be pumped against including suction lift friction head, velocity head

TABLE 78. ONE PUMP ONE MOTOR RETURN LINE SYSTEM

Size	Sq. Ft. Direct Equivalent Radiation Surface	Diameter Orifice Vacuum 10 In.	Air Capacity Cu. Ft. per Min.	Water Capacity Gals. per Min. 10 Lb. Pressure 180° F.	Actual H. P.	R. P. M.	H. P. of Motor
A	8000	9-64	6	11	0.9	1800	1
B	16,000	3-16	11	22	1.4	1800	1½
C	26,000	1-4	19	35	2.0	1800	2
D	40,000	9-32	25	60	2.8	1200	3
E	65,000	3-8	42	90	3.9	1200	5
F	100,000	1-2	75	140	9.0	1200	10
G	150,000	9-16	90	200	10.0	900	10
H	250,000	Three 1-2	180	400	10.0	720	20

TABLE 79. TWO PUMP ONE MOTOR RETURN LINE SYSTEM VACUUM PUMPS

Capacity Sq. Ft. of Direct Radiation	Capacity G. P. M.	Pressure at Pump	Motor H. P.
6000	9	10	¾
6000	9	15	1
8000	12	10	1
8000	12	15	1½
12,000	18	10	1
12,000	18	15	1½
18,000	27	10	1½
18,000	27	15	2
30,000	45	10	2
30,000	45	15	3

TABLE 80. TWO PUMP TWO MOTOR RETURN LINE SYSTEM VACUUM PUMP

Capacity Sq. Ft. of Direct Radiation	Capacity G. P. M.	Pressure at Pump	Motor H. P.	
			Air	Water
6000	9	10	½	¾
6000	9	15	½	¾
8000	12	10	½	¾
8000	12	15	½	1
12,000	18	10	¾	¾
12,000	18	15	¾	1
18,000	27	10	¾	1
18,000	27	15	¾	2
25,000	38	10	1	1½
25,000	38	15	1	2
30,000	45	10	1	1½
30,000	45	15	1	2

and head against which the pump must discharge. The vacuum under which return pumps are required to operate and as to whether two or more units are to operate in parallel or separately.

INSTALLATION DATA

All pumps should be set on substantial foundations and be provided with heavy cast iron sub-bases, securely anchored to foundation and provided with drip ring with drain properly connected to sump or sewer.

The exhaust from steam driven pumps supplying steam for heating purposes should be taken through an efficient 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.

Motors should be not less than ⅓ greater in horsepower than that actually required to drive the pump under full load conditions.

CHAPTER X

WARM-AIR FURNACE HEATING*

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 the Chapter XIX on Design and Construction of Air Ducts. Complete engineering data, including the procedure to be followed in designing a typical system, are presented in the first part of the chapter, while the last part of the chapter presents a Standard Code Regulating the Installation of Warm-Air Heating Furnaces in Residences, approved by the *National Warm Air Heating and Ventilating Association*, AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS, *National Association Sheet Metal Contractors*, *Western Warm Air Furnace and Supply Association*, and the *Midland Club*, 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 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 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, or the air supply may be taken (2) entirely from outside the building, in which case no air is recirculated. Sometimes 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 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.

*Material for this section was prepared especially for THE GUIDE by Arthur 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.

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 and Ventilating 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 sq. in. of leader pipe per hour for first, second or third floors is shown by Fig. 48 at 175 deg. fahr. to be 105, 170 and 208 B.t.u. respectively. For average calculations, the values 110, 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:

$$\text{Leader areas for first floor, square inches} = \frac{H}{110} = \text{approximately } 0.009H \qquad (1)$$

$$\text{Leader areas for second floor, square inches} = \frac{H}{166} = \text{approximately } 0.006H \qquad (2)$$

$$\text{Leader areas for third floor, square inches} = \frac{H}{200} = \text{approximately } 0.005H \qquad (3)$$

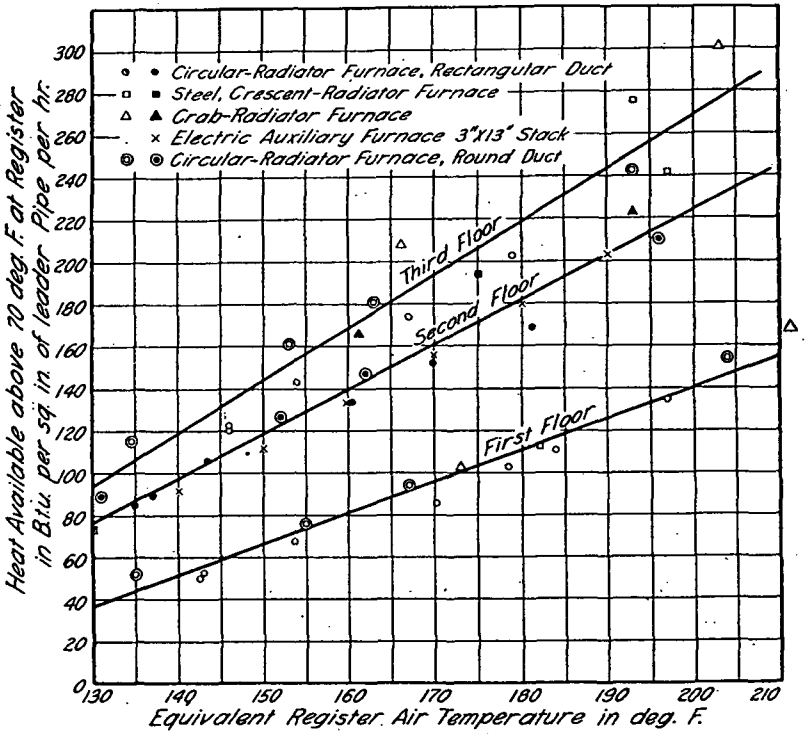


FIG. 48. VALUE OF SQUARE INCH OF LEADER PIPE AREA FOR FIRST, SECOND, AND THIRD FLOORS

In designing for a lower warm-air register temperature, say 160 deg. fahr., the factors 110, 166 and 200 become 80, 140 and 166 (Fig. 48 at 160 deg. fahr.), and the resulting equations are:

$$\text{Leader areas for first floor, square inches} = \frac{H}{80} = \text{approximately } 0.012H \qquad (4)$$

$$\text{Leader areas for second floor, square inches} = \frac{H}{140} = \text{approximately } 0.007H \qquad (5)$$

$$\text{Leader areas for third floor, square inches} = \frac{H}{166} = \text{approximately } 0.006H \qquad (6)$$

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. 48 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. 49.

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

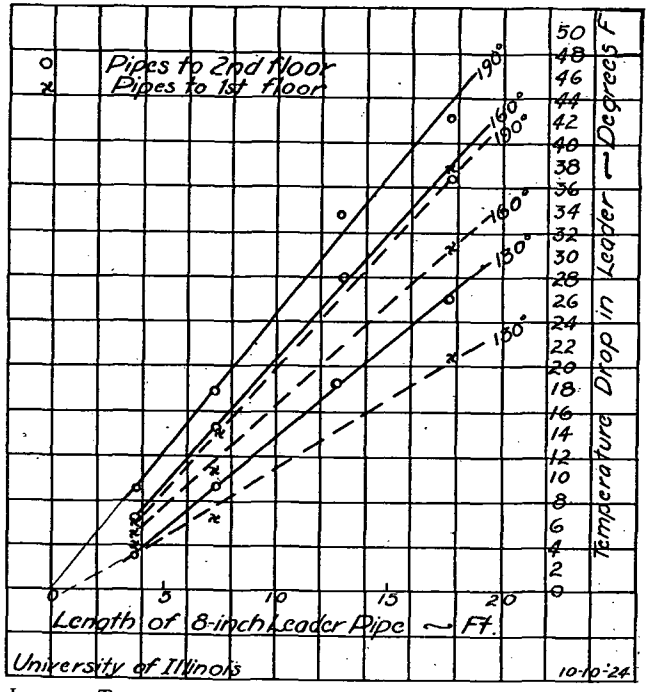


FIG. 49. LOSS IN TEMPERATURE IN 8 IN. LEADER PIPE OF VARIOUS LENGTHS AT DIFFERENT REGISTER TEMPERATURES

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. 48. So long as the leader is short and straight as was the case for Fig. 48, such a practice is probably justified since the loss (Fig. 50) in capacity occasioned by the smaller stack is not very serious for ratios above 70 per cent. 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 greater temperature losses (Fig. 49) in the longer leader. In gravity circulating systems, this stack to leader

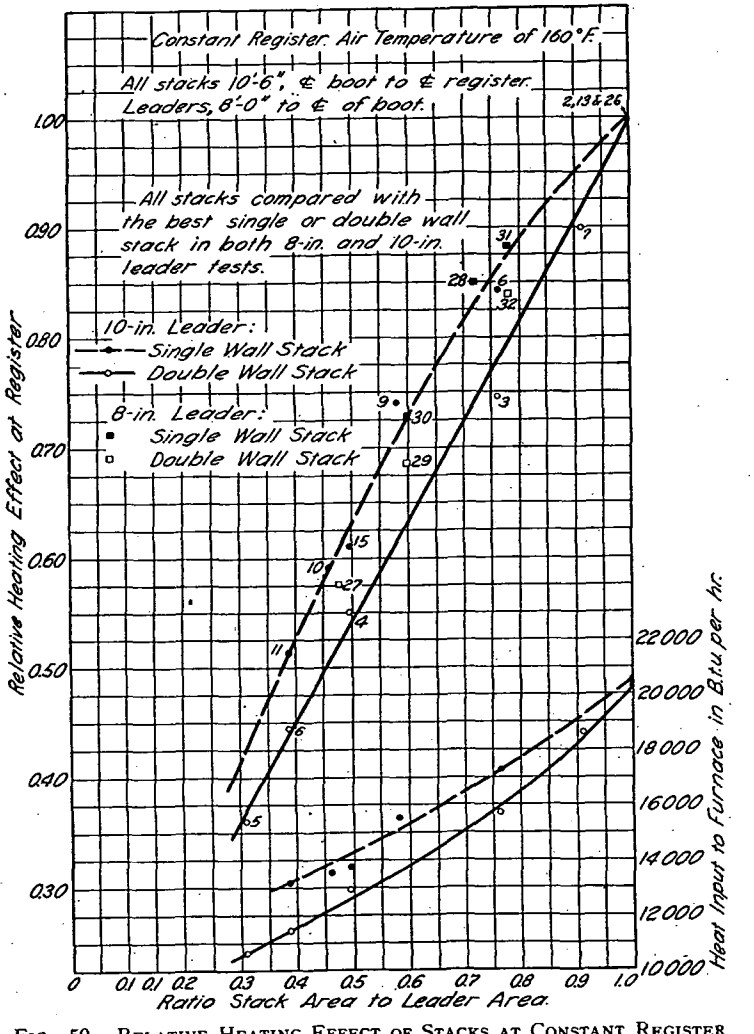


FIG. 50. RELATIVE HEATING EFFECT OF STACKS AT CONSTANT REGISTER AIR TEMPERATURE

area ratio is a very important consideration. Specific data for a great variety of cases are presented in Figs. 51 and 52 and the designer should check his stack to leader combinations with the nearest comparable case as shown in these figures. Any second floor stack supplying heat

to a room whose heat loss is 9000 B.t.u. or above. (See Figs. 51 and 52 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

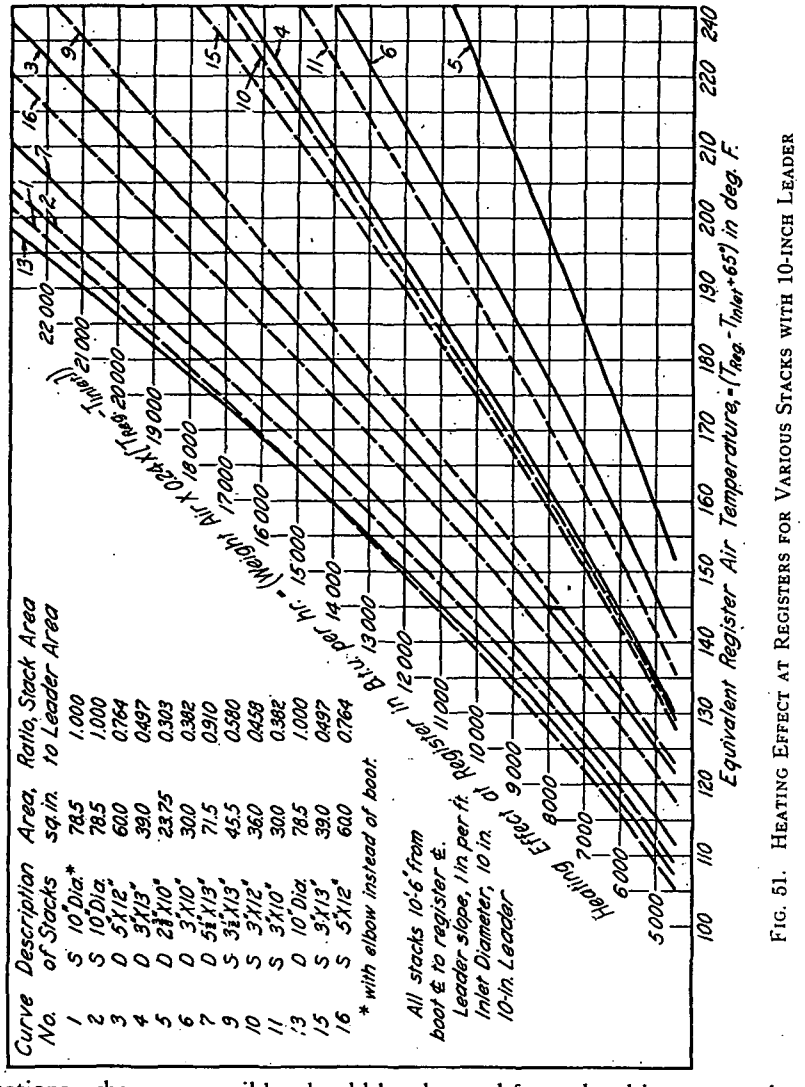


FIG. 51. HEATING EFFECT AT REGISTERS FOR VARIOUS STACKS WITH 10-INCH LEADER

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. Splitters in the upper end of the duct increase the air discharge.

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

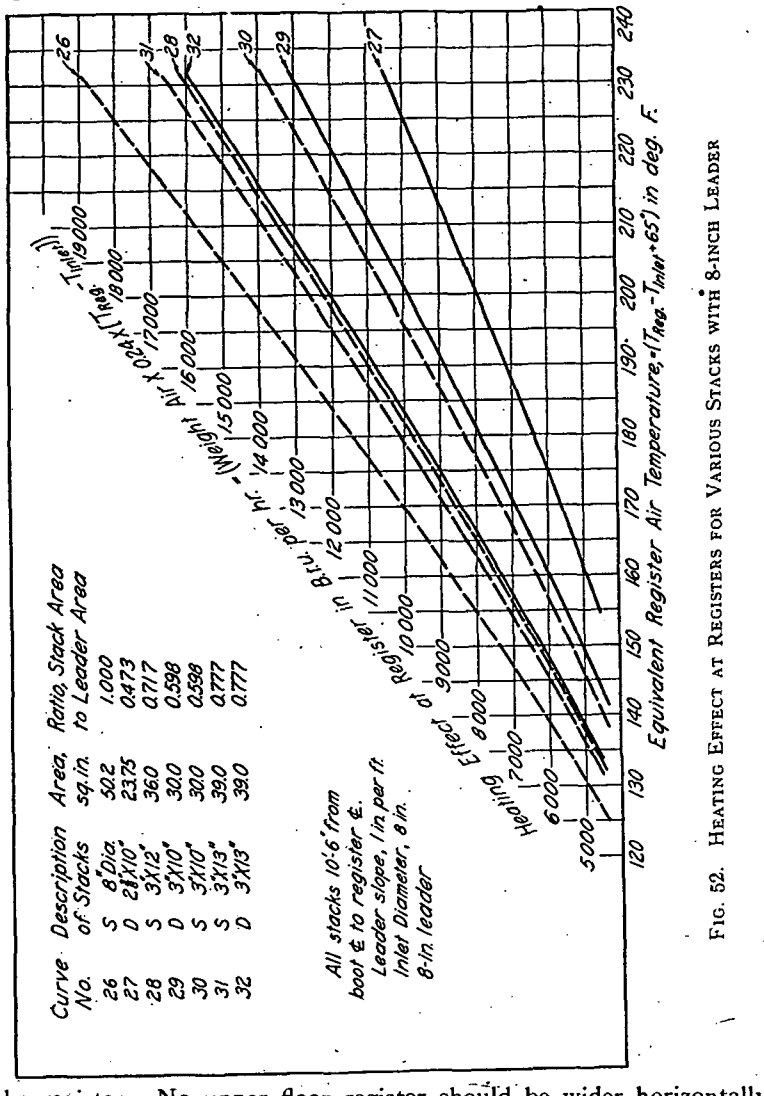


FIG. 52. HEATING EFFECT AT REGISTERS FOR VARIOUS STACKS WITH 8-INCH LEADER

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, and not in the floor. First floor registers may be of the base-

board 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.

AIR SUPPLY DUCTS

Ducts for recirculating air from the house or for bringing in outside air should be as short and direct as possible. The areas of such ducts should never be less than the combined areas of all warm-air leaders and ducts of the recirculating type may be made even larger than the total leader area. The importance of running the air supply ducts as direct

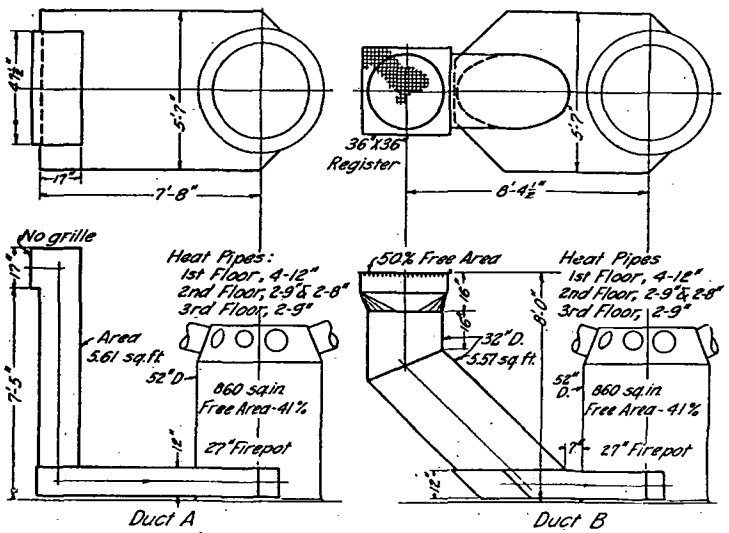


FIG. 53. TWO TYPES OF RECIRCULATING DUCT TESTED

as possible without sharp elbows is shown by the comparative performance on the same plant of two ducts (Fig. 53), as presented in Table 81.

In both cases a very wide low shoe was used for connecting the ducts to the back of the furnace casing. The top of this shoe should never enter the casing above the level of the grate in the furnace, and to accomplish this the shoe must be wide. The superior performance of

TABLE 81. HEAT AVAILABLE AT REGISTERS FOR TWO TYPES OF RECIRCULATING DUCTS

REGISTER AIR TEMPERATURE DEG. FAHR.	HEAT AVAILABLE AT REGISTERS ABOVE 70 DEG. FAHR. B.T.U. PER HR.		PER CENT INCREASE FOR ROUND DUCT
	Rectangular Duct	Round Duct	
130 (Low)	47,000	54,000	15.0
160 (Moderate)	81,000	94,000	16.0
190 (High)	120,000	138,000	15.0

the round duct using two 45 deg. instead of two 90 deg. elbows is very apparent. Values given in Fig. 48 are based on such a duct. Outside duct connections, if used, should be made to a window frame the full area of duct and such window should be in a wall exposed to prevailing winter winds. The inside type of recirculating duct or ducts is always preferred for residence installations.

RECIRCULATING REGISTERS

The register through which the air in the building is returned to the furnace should always be placed in a central position in the first floor, usually in the main hall if one exists. Air from the upper floors must have free access to this register through the stairway of the building. Sometimes more than one return air register is found desirable, and such multiple returns are often justified. The recirculating registers should have a free area at least equal to the duct to which they connect, and their free area should never be less than 50 per cent of their gross area.

FURNACE

The size of furnace should, of course, be such as will provide the necessary air heating capacity, usually expressed in square inches of 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. 54) 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. 54. 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. 54) 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. 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):

$$\text{Grate area (175 deg. register temperature), square inches } \frac{1.2\ H}{356} = 0.0034H^* \quad (7)$$

$$\text{Grate Area (160 deg.), square inches } = \frac{1.2\ H}{300} = 0.0040H^* \quad (8)$$

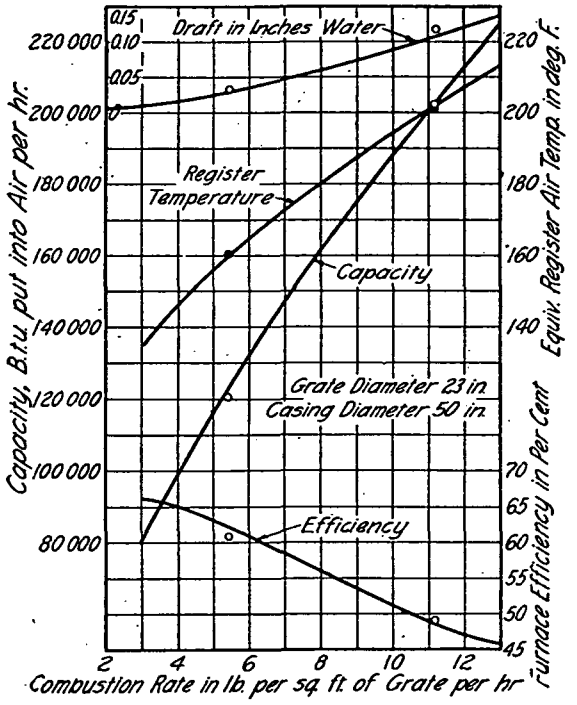


FIG. 54. TYPICAL PERFORMANCE CURVES FOR A WARM AIR FURNACE AND INSTALLATION IN A THREE-STORY TEN LEADER PLANT, OPERATING ON RECIRCULATED AIR

As a check upon the method of selection by performance curves, the method of selecting the furnace which has been in general use is as follows:

*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.

Let E = efficiency of the furnace
f = fuel value of the coal in B.t.u. per pound
p = pounds of coal burned per square foot of grate surface per hour and the formula then becomes

$$\text{Grate area, square inches } = \frac{1.2 \times 144\ H}{E\ f\ p} \text{ if all inside air} \quad (9)$$

For coal having a heat value of 12,000 B.t.u., a furnace having 60 per cent efficiency and 6 lb. of coal burned per sq. ft. of grate per hour, this becomes:

$$\text{Grate area, square inches } = \frac{1.2 \times 144\ H}{0.60 \times 12{,}000 \times 6} \text{ for all inside air} \quad (10)$$

The air temperature at the registers corresponding to the conditions covered by equation (10) would be approximately 160 deg. fahr. and for 175 deg. fahr. and 12,000 B.t.u. the combustion rate should be at least 7.5 lb. with an efficiency of about 57 per cent, using curves of Fig. 54 as a guide.

CHIMNEYS

The construction, location, height and area of the chimney to which the 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 continuous 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 brick work 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.

The size or area of flue lining or of brick flue 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



FIG 55. ELEVATION OF THE WARM AIR RESEARCH RESIDENCE

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 often unsatisfactory in operation and hence should be avoided.

TYPICAL EXAMPLE

The application of the preceding data to an actual example may be of assistance to the designer. Figs. 55, 56, 57, 58 and 59,* represent the plans of the Warm Air Research Residence of the *National Warm Air Heating and Ventilating Association* recently erected at the University of Illinois.

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)

*Plans used with permission and bath room on third floor not heated at present.

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

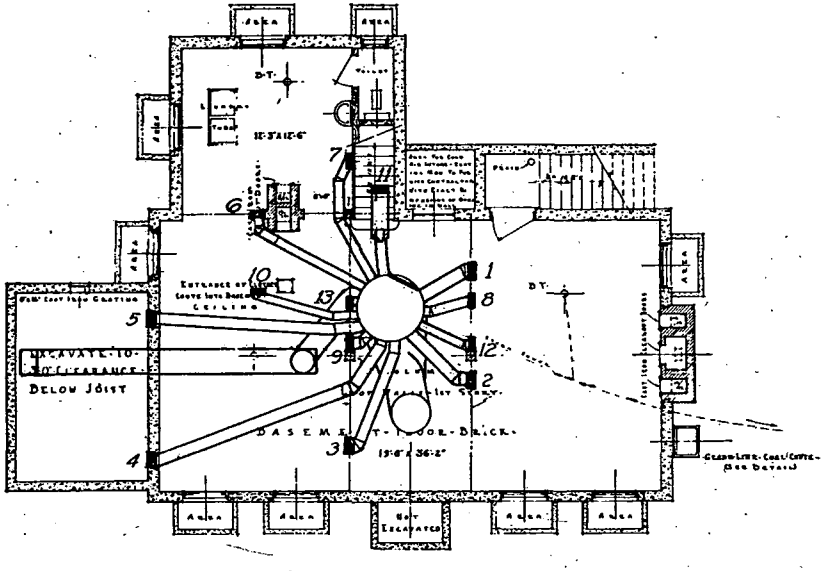


FIG. 56. BASEMENT PLAN

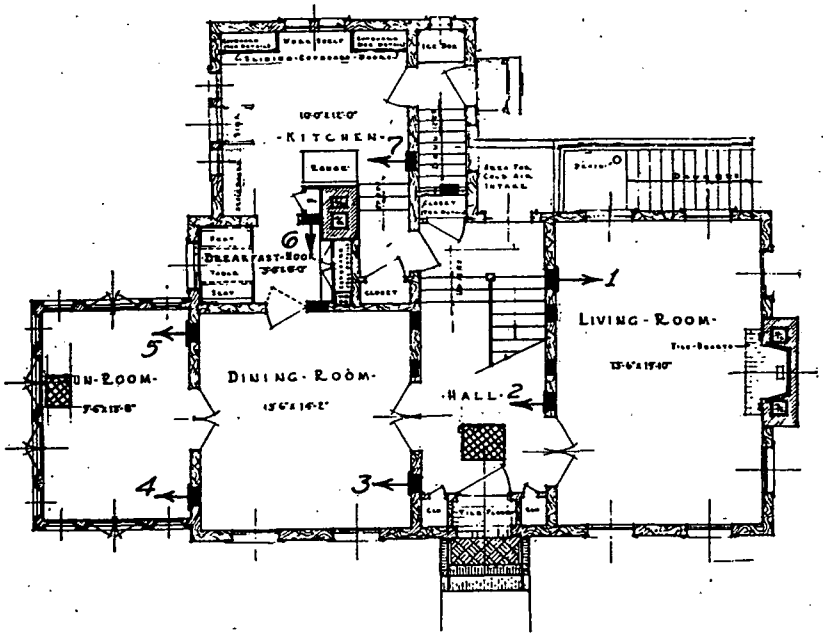


FIG. 57. FIRST FLOOR PLAN

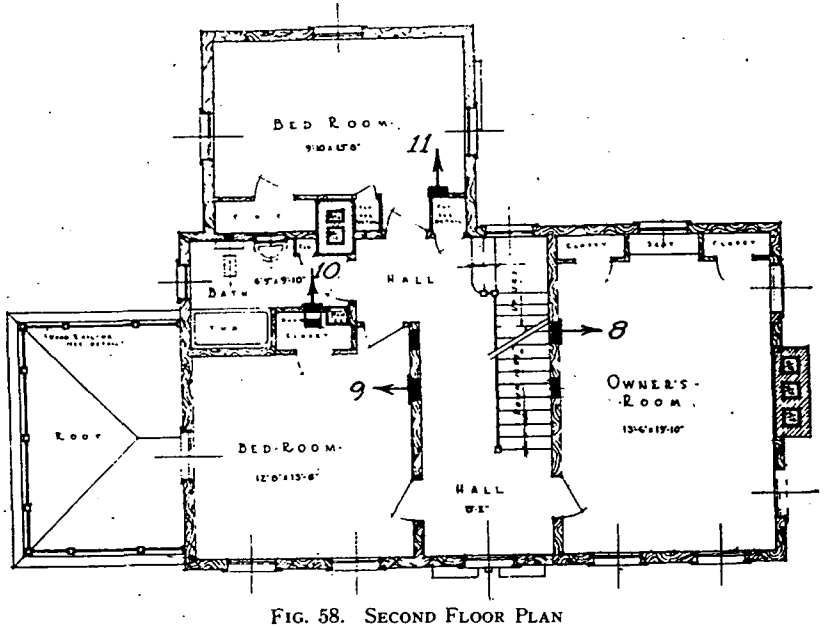


FIG. 58. SECOND FLOOR PLAN

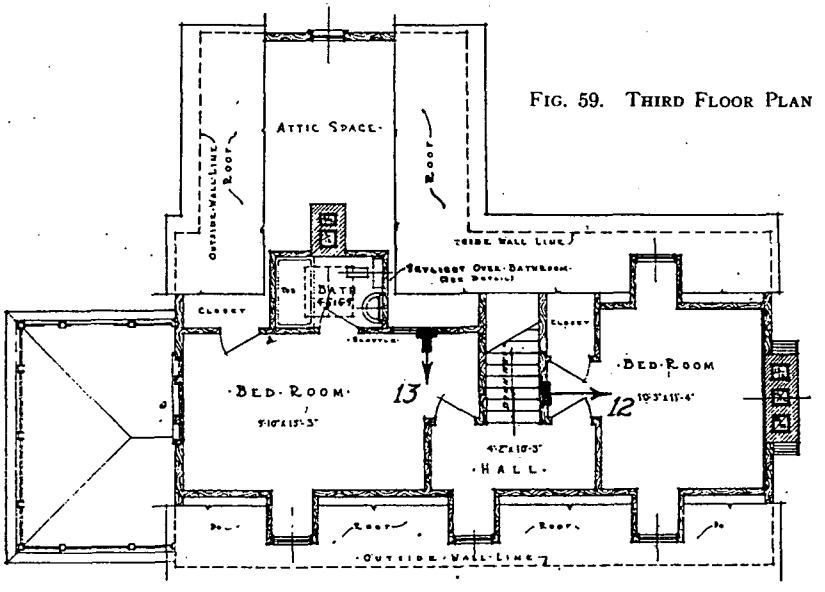


FIG. 59. THIRD FLOOR PLAN

STANDARD CODE REGULATING THE INSTALLATION OF WARM AIR FURNACES IN RESIDENCES*

THIRD EDITION
June 1, 1924

*This Code is approved and issued by authority of the *National Warm Air Heating & Ventilating Association*, THE AMERICAN SOCIETY OF HEATING & VENTILATING ENGINEERS, *National Association Sheet Metal Contractors, Western Warm Air Furnace and Supply Association* and *The Midland Club*.

ARTICLE 1.—Meaning of the Term "Warm Air Furnace Heating Plant"

Warm air furnace heating plants, 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, boxes and fittings, smoke pipes and fittings, registers, borders and face plates, the same being intended for heating buildings in which they may be installed.

ARTICLE 2.—Provisions to be made in Building under Construction for Reception of Warm Air Furnace Heating Plants

Section 1. a The following provisions shall be made by the owner or building contractor, in any building wherein a warm air heating plant 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 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 1.—It is strongly recommended that the attic be tightly floored to reduce heat losses.

d All partition walls (or sections of these walls) in which heat stacks to second floor rooms are to be installed, shall be built of six-inch (6″) studding to second story floor joists.

Chimneys

Section 2. *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 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 nor create a ledge or obstruction, where loose material may lodge.

f Its narrowest internal dimension shall not be less than eight (8″) inches and no flue smaller than 8″ x 8″ rectangular or eight (8″) inch diameter round will be considered suitable when hard coal is to be burned, or 8″ x 12″ rectangular or ten (10″) inch 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 2.—It is recommended that the height above the furnace grate be not less than twenty-six (26′) feet.

Note 3.—It is strongly recommended that all new chimneys be built in strict accordance with the ordinance recommended by the National Board of Fire Underwriters.

ARTICLE 3.—Method for Determining Size of Warm Air Pipes, Wall Stacks and Furnaces for Use in a Residence

Method of Determining Size of Basement Warm Air Pipes

(Read Explanatory Notes 4 to 11

Section 1. First Floor Rooms.

Divide square feet of glass by 12,
Divide square feet of net outside wall by 60,
Divide cubic contents by 800,
Add together the above and multiply by 9.
The result is the area of the basement pipe.

$$\left\{\begin{array}{l}\text{The sum of:}\\ \text{Glass (sq. ft.) } (\textit{Note 4}) \div 12\\ \text{Net Wall (sq. ft.) } (\textit{Note 5}) \div 60\\ \text{Cubic Contents} \div 800\end{array}\right\} \times 9 = \text{Area of Basement Pipe } (\textit{Note 10})$$

Section 2. Second Floor Rooms.

Divide square feet of glass by 12,
Divide square feet of net outside wall by 60,
Divide cubic contents by 800,
Add together the above and multiply by 6.
The result is the area of the basement pipe.

$$\left\{\begin{array}{l}\text{The sum of:}\\ \text{Glass (sq. ft.) } (\textit{Note 4}) \div 12\\ \text{Net Wall (sq. ft.) } (\textit{Note 5}) \div 60\\ \text{Cubic Contents} \div 800\end{array}\right\} \times 6 = \text{Area of Basement Pipe } (\textit{Note 10})$$

Section 3. Third Floor Rooms.

Divide square feet of glass by 12,
Divide square feet of net outside wall by 60,
Divide cubic contents by 800,
Add together the above and multiply by 5.
The result is the area of the basement pipe.

$$\left\{\begin{array}{l}\text{The sum of:}\\ \text{Glass (sq. ft.) } (\textit{Note 4}) \div 12\\ \text{Net Wall (sq. ft.) } (\textit{Note 5}) \div 60\\ \text{Cubic Contents} \div 800\end{array}\right\} \times 5 = \text{Area of Basement Pipe } (\textit{Note 10})$$

Method of Determining Size of Wall Stacks

Section 4. First Floor Rooms.

Same as Section 1.

Section 5. Second Floor Rooms.

Deduct 30 per cent from basement pipe area determined in Section 2.

Section 6. Third Floor Rooms.

Deduct 30 per cent from basement pipe area determined in Section 3.

Explanatory Notes

Note 4.—In obtaining glass surface use full casement opening. An outside door is figured as glass.

Note 5.—To obtain net outside wall multiply height by width and deduct the glass in all windows and outside doors.

Note 6.—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 7.—For cold ceilings, add one-half net area of ceiling to net exposed wall (cold ceilings are those next to unfloored attics.)

Note 8.—Use no warm air pipe less than 8 inches in diameter. If a basement warm air pipe figures greater area than any standard commercial size then the next larger size shall be used.

Note 9.—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 feet in length. Sharp turns and long pipes should have extra capacity.

Note 10.—These formulae are for 70 deg. inside temperature with zero temperature outside. For a temperature of 10 deg. below zero, add 10 per cent to the capacity of each pipe.

Note 11.—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 2-room volumes use the figure 400. "The factors 9, 6 and 5 in sections 1, 2 and 3 are calculated for a register air temperature of 175 deg."

Transition Fittings and Stacks

Section 7. Transition from warm air pipes to stacks shall be made with a well-designed elbow or boot and no stack shall be less than 70 per cent of the warm air pipe area.

Method of Determining Size of Registers

Section 8. All registers shall have a free area at least equal to the calculated area of the basement pipe.

Method of Determining Size of Furnace

Section 9. Add together the actual warm air pipe areas in square inches as obtained in Sections 1, 2 and 3, and select a furnace having a free area not less than the sum of all the warm air pipe areas.

ARTICLE 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. Furnace foundation of brick, cement, or other incombustible material must be provided. Said foundation to extend at least fifteen (15″) inches at rear and sides of furnace casing and at least thirty-six (36″) inches in front of furnace casing. Foundation to be level.

Setting or Assembling of Furnace

Section 3. *a* The base ring of the furnace shall be cemented to the foundation, 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 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 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 (8″) inches be maintained between the top of any furnace and the top of casing or bonnet.

d Any furnace, the casing top of which shall come within sixteen (16″) inches of a combustible floor, ceiling or joist, shall be protected by a metal shield, extending not less than eighteen (18″) inches beyond the casing of said furnace. This shield shall be suspended at least two inches below wood work, allowing free air space between shield and woodwork. No furnace casing or top, coming nearer than six (6″) inches of ceiling or joists shall be allowed in any case.

e Openings for side casing collars shall be cut into the casing top, 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 set, cement or hollow tile casings shall be constructed as follows: Walls shall be not less than eight (8″) inches in thickness, and shall be constructed air tight. Rectangular casing shall be, with least inside dimensions, 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 (8″) inches 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 even with the top of the collars, lay spacing rods of bar iron on edge or angle irons across the furnace top, cover these with sheet iron, cover the sheet iron with masonry and run the side walls four (4″) inches above the masonry bed. A galvanized iron casing bonnet may be used on brick set furnaces.

Provisions 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 (1¼″) inches and such joints shall be beaded and soldered or riveted. All pipes shall be properly secured to ceiling or joist. No solder or riveted joint is required where round pipe slips over the casing collar. Any pipe twelve (12″) inches or greater in diameter shall not be made of material lighter than IX tin or No. 26 U. S. Standard Gauge galvanized iron.

Note 12.—It is recommended that all warm air pipes in the basement shall have an upward pitch of not less than one (1″) inch per running foot.

b. No warm air pipe shall run within one (1″) inch of any woodwork unless such woodwork is covered with asbestos paper and the paper covered with tin or iron.

c. All warm air pipes in the basement shall be provided with dampers not more than two feet from the casing.

d. 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 lbs. per one hundred (100) sq. ft. 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 three-eights (⅜″) 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 (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 pipes 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 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 and soldered and the several members shall be attached to each other with slip joints, which are, for the purpose intended, air 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 (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. The warm air registers in the various rooms shall be located in or near the inside walls in all cases.

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.

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.

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 (80%) per cent 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 air tight. 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 overhead, 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 six (6″) inches 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. 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 (1″) inch of the floor line.

The free area of cold air faces shall be at least 10 per cent in excess of the free area of the duct or ducts to which they are connected.

Note 13.—The effective area of a vertical cold air face lies within twelve (12″) inches 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 twelve (12″) inches in height and deducting for the grills or cross bars.

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 either black or galvanized iron not lighter than No. 24 U. S. Standard Gauge, and of the full size of the collar on the furnace throughout its entire length. It must have no other opening for attaching any fire place, 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 (1½″) inches and it shall be rigidly secured. Cast iron smoke pipe may be used.

b. 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 (18″) inches 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 wood at all points.

c. No smoke pipe shall project through any external wall or window.

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. Article 4, Section 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 furnace be allowed closer than twelve (12″) inches to any ceiling or joists above the furnace.

b. Where joists are cut to accommodate this furnace, headers shall be put in and braced so as not to weaken the structure of the floor above the furnace.

c. Article 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 Article 4, Sections 5 and 8 shall apply.

CHAPTER XI

OIL FUEL FOR INDUSTRIAL AND DOMESTIC HEATING

INDUSTRIAL OIL BURNING

OIL has established its place in the heating field first in the industrial and more recently in the domestic service where effective methods have been devised to burn it economically under automatic control. The engineer, architect and contractor should have a fundamental knowledge of its characteristics, its applications, and should know some of the practical phases of installation methods in new and existing plants. Specific data is necessary for successful service of a plant and for the protection of the client's interests. Every installation should be a matter of individual and careful study.

Oil as a fuel is desirable because it is liquid in form, being petroleum in its constituent parts. 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 heating engineer must figure out the operating cost both with coal and with oil, 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.

Crude oil has either a paraffin or asphalt base, or a blending of the two. Fuel oil, is heavy, dark in color and has a greater viscosity, higher calorific value and higher flash point than the crude oil from which it is made. It results from the distillation of crude oil during which processes naptha, benzine, gasoline, kerosene and other distillates are removed. The character of the fuel oil varies in accordance with the extent to which the crude oil has been refined.

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 Baumè gravity, viscosity, flash point, and cold test, or temperature at which it will cease to be fluid.

The following table gives data from standard authorities on various oils. The flash point varies considerably in the oils from different fields, hence the figures given are subject to variation.

Compiled especially for THE GUIDE by Byron K. Eaton, chief engineer, Winslow Boiler & Eng. Co., Chicago, Ill.

TABLE 82. DATA ON FUEL OILS

OIL	BAUME GRAVITY DEG. FAHR.	FLASH POINT DEG. FAHR.	POUNDS PER GALLON	B.T.U. PER GALLON	B.T.U. PER LB.
Kerosene	42	140	6.80	135,524	19,900
Distillate	38	160	6.96	137,402	19,700
Light Gas Oil	36	190	7.03	138,421	19,700
Dark Gas Oil	32	200	7.21	140,811	19,600
Light Fuel Oil	24	150–200	7.58	145,612	19,000
Heavy Fuel Oil	18	180–280	7.89	149,484	18,900

Note. While the use of an oil may be contemplated, having a cold test sufficient to meet the lowest temperatures experienced, if there is any possibility of higher cold test oils being used, heating coils should be installed either in the storage tank or elsewhere in the system.

AIR REQUIRED FOR OIL BURNING*

PER CENT CO_2 BY VOLUME OF DRY GASES	LIGHT OIL		MEDIUM OIL		HEAVY OIL	
	Lb. of Air per Lb. of Oil	Excess Air Per Cent	Lb. of Air per Lb. of Oil	Excess Air Per Cent	Lb. of Air per Lb. of Oil	Excess Air Per Cent
4	51.40	260.7	51.93	270.4	52.45	280.3
5	41.31	189.9	41.71	197.5	42.12	205.4
6	34.58	142.7	34.90	149.0	35.23	155.4
7	29.77	108.9	30.04	114.3	30.31	119.8
8	26.17	83.6	26.39	88.3	26.62	93.0
9	23.37	64.0	23.56	68.0	23.75	72.2
10	21.12	48.2	21.29	51.8	21.45	55.5
11	19.83	39.1	19.43	38.6	19.58	41.9
12	17.76	24.6	17.88	27.6	18.01	30.6
13	16.46	15.5	16.57	18.2	16.69	21.0
14	15.36	7.8	15.45	10.2	15.55	12.7
15	14.39	1.0	14.48	3.3	14.57	5.6

*C. R. Weymouth, *Transactions, American Society Mechanical Engineers*, Vol. 30. Also see Vol. 34.

A fuel oil burner installation comprises oil storage, pumping equipment, heating equipment if required, an atomizing assembly and a correctly designed fire-box within the boiler for complete combustion and for proper diversion of the fire and gases. There are certain essential accessories, such as pipelines, oil pre-heaters, regulating valves, meters, strainers, pressure gages, relief valves and the proper adaptation of them all to the particular needs of each specific case.

It is not the purpose of this article to discuss the relative merits of various types of burners. The respective claims of burner manufacturers can be carefully weighed and a decision made as to which is best adapted to the work in question. Mechanical simplicity and the assurance of correct principles of atomization should be of foremost consideration in judging burners.

The decision as to the burner will govern the type of oil pump utilized to draw the oil from the storage tank and introduce it into the burners. The various burner campanies have provided what they consider the most suitable pumping devices for their equipment.

One of the most important phases of oil burner installations, is the design of the combustion chamber of the boiler or furnace. While the consumption of coal is limited in a boiler, by the square feet of grate and the draft available where handfiring is utilized, with oil burning equipment, the only limit to the oil consumption, is in the cubical contents of the combustion chamber or fire-pot. Practically any of the boilers that

are in use today are adaptable to oil burning equipment but there should be a rearrangement of the combustion chamber. The grates may be removed, and the burner dropped below their level thus enlarging the combustion space.

A wide, long, high combustion chamber is ideal, within certain limits. It is only necessary to extend protecting walls where there are water-drop legs projecting downward from the crown-sheet. All such water surfaces must be protected from any direct contact with the fire. It is well to brick up the sides of boilers, of fire-box or sectional type, to a point 8 or 9 in. higher than the center-line of the burners. Impingement walls should be so built as to properly deflect the gases of combustion.

The brick used should be of the very highest heat-resisting type and each brick should be dipped in a thin batter of heat-resisting cement and water and laid up tightly to the next brick. This will give a very excellent wall which will require a minimum of attention. Oil burner manufacturers have plans for the bricking of the various types of boilers, which plans are usually submitted after the contract has been approved.

There are a number of oil heaters on the market, which are meritorious. If low pressure steam boilers are being equipped with oil burners, ordinary coil waterheaters may be connected below the water-line of the boiler. Sufficient heating capacity should be installed to bring the temperature of the oil up to within 25 or 30 deg. of its flash-point. This pre-heating of the oil not only decreases the viscosity but takes a certain combustion burden from the fire in the boilers and also tends to carry in suspension basic deposits which might otherwise be left in the burners. In high pressure work, coil heaters can be connected into the exhaust or live steam lines depending upon the type of heater selected.

Naturally, the heavier the oil, the greater will be the tendency towards sediment deposit consequently strainers must be provided. Unless the oil is exceedingly heavy, a single strainer in the suction line just before it enters the pumping equipment, will be sufficient. This strainer can be so built as to be easily accessible for cleaning. In some instances, duplex strainers are used, in which case, the mere throwing of a lever, will change the flow of oil from one strainer to another, so that cleaning can be accomplished without interfering with the supply of oil.

The question of the elevation of the pump is of some importance, as some communities prohibit the installation of oil pumping equipment at a point lower than the top of the oil storage tank. As the result, it is frequently necessary to build platforms in the boiler-room on which to mount the pumping equipment, so that there will be no danger of siphoning. If this is not done anti-siphoning devices should be used.

While fuel oil burners are not automatic in character, yet a great many burner companies provide automatic regulators to maintain a fire between "high-low" limits, so as to maintain uniform pressures.

The foregoing discussion refers continually to boilers, it must not be lost sight of that oil fuel is adaptable to scores of industrial purposes. Bake ovens, melting pots, annealing furnaces, dryers and countless other heat demanding units are continually and adequately operated with this modern fuel.

Adequate oil storage should be planned. Where trackage is available,

carload deliveries should be provided for. Local ordinances and the requirements of the *National Board of Fire Underwriters* and the local bureau having jurisdiction should be studied and strictly adhered to, especially in the matter of locating and burying outdoor tanks and in the brick-housing and sand-fill usually required for large interior tanks that are not buried.

Where the storage tank is buried outside the building, the oil suction, oil return and the steam flow and return lines should all be run in one large split tile, carefully cemented. The steam line should then drop into the oil storage tank, either spirally around the suction line, thence returning through the tile, to discharge into the heating system trap, or the coil can extend to and be laid along the bottom of the tank, with the return similarly returning to the steam system. Great care should be exercised in the construction of steam lines inside of oil tanks, so that there will be absolutely no possibility of a leakage from the oil into the steam coils when coils are under a vacuum or of the steam leaking into the oil.

Every tank should be provided with a man-hole and with the following tappings:

4	in. fill	1½ in. return	1½ in. steam flow
3	in. suction	1½ in. vent	1½ in. steam return

All these tappings should be in the top of the tank. The suction pipe should not extend closer than six inches to the bottom of the tank. These tappings can be varied in size to suit local ordinances or conditions.

There are two general types of tanks—vertical steel and horizontal steel. Up to 10,000 gal. the horizontal steel tank is commonly used; the vertical steel tank is used for larger capacities.

Since the minimum car of oil is 8,000 gal., it is well not to plan any tankage of less than 10,000 gal. capacity, where carload deliveries are possible. Where oil companies maintain reserves of oil, smaller storage can be provided for than in districts where all the oil has to be brought in by car. In this case, there should be enough storage for a reasonable period. One ton of coal is equivalent to approximately 170 gal. of fuel oil.

Standard construction for underground horizontal steel tanks provides 3/16 in. steel for up to 4,000 gal., ¼ in. from 4,000 to 10,500, 5/16 in. from 10,500 to 20,000 gal. Vertical above ground tanks should be built in accordance with the Underwriter's tables for diameter and height.

While oil consumption can be fairly accurately checked by gaging the tank, the oil meter is the most logical method of quickly determining fuel costs and in estimating the relation between fuel consumption and work performed.

DOMESTIC OIL BURNERS

The problem of applying oil fuel to residential heating is essentially different from that pertaining to industrial installations. While in an industrial installation the size of the plant usually warrants the necessary investment for installing auxiliary equipment for preheating and atomizing the heavy fuel oils such investment is seldom warranted in the small plant required in a residence. Further, the hazard associated with preheating and the complication incident with atomization is an added

factor weighing against the use of heavy oils for this purpose. These facts results in the use of lighter or higher Baumè gravity oils for domestic purposes. These oils which include gas oil, distillate, and kerosene are liquids of low viscosity even at zero temperature.

Every manufacturer supplies complete information relative to the handling of the equipment, which should be mounted in the boiler-room.

The safety devices demanded by the Underwriters' Laboratories are varied, dependent upon the type of the equipment used, but the owner should familiarize himself with their purpose and care.

Noise may be divided into two kinds: (1) Purely mechanical and (2) noise of combustion. The former will depend upon the equipment used and its complication of mechanism. Combustion noise should be approximately the same in nearly all burners. Where the correct adjustment of air and oil is made to give the best efficiency, this combustion noise will be cut to a minimum. Any boiler that is heavily covered with insulating material will permit the transmission of less noise than an uncovered boiler.

The thermostatic equipment should consist of a room thermostat, centrally located in a position, representative of the general home temperature, remote from any source of heat or cold, and a boiler control to prevent the temperature of the water or the steam pressure from exceeding a predetermined point.

While oil burners are most successfully operating in hundreds of different makes and styles of boilers and furnaces yet in planning new heating systems the adaptability of boilers to oil burning should be given serious consideration. Generally speaking, boilers with a preponderance of indirect or flue surfaces, are best suited to oil burning, because an oil fire develops a considerably hotter flame than does coal. This means higher combustion gas temperatures, and naturally demands more heat absorbing, water-backed flue surfaces.

The problem of fuel consumption in residential heating plants is just as vital when an oil burner is used as with any other style of fuel. The factors that determine fuel consumption are:

Boiler efficiency
Heating plant efficiency
Temperatures carried
Normal heating demands
Abnormal heat losses
Burner adjustment.

It is not necessary to discuss these factors, with the exception of the last.

The proper adjustment of oil and air and the maintenance of that adjustment under varying draft conditions is important.

Fires misadjusted to a white color are obviously using an excess of air at the sacrifice of efficiency. The orange flame, with a minimum of excess air, constitutes what we term a "lazy, floating fire," which gives ample opportunity for the heat units to transfer themselves into the heating medium behind the walls of the boiler and its flues.

Where round domestic boilers are contemplated, those with a maximum number of horizontal water sections above the fire-box are to be preferred.

In selecting burner sizes the total load imposed upon the boiler and thence upon the burner should be carefully determined. This load should be determined in accordance with the method for determining the load on any boiler as outlined in preceding chapters.

The same allowance for hot water heaters should be made as for ordinary boiler practice and the same precaution should be followed in insulating the boiler and piping.

Draft is a matter of importance, since the quantity of air introduced by the very essential motor driven burner fan, must have adequate opportunity to pass freely into the stack. The standard practice of assigning an individual flue to the heating boiler should be strictly adhered to.

Oil burners with their frequent periods of idleness, and the consequent elimination of needless fuel consumption, do not always impart sufficient heat to ordinary water coils in the fire-pot of heating boilers.

Where vapor or steam is used, any of the boiler water-heating units that connect into the boiler below the water-line, thus heating the storage tank, should be used. In hot water heating plants, larger coils are necessary.

In studying the burner equipment itself, attention should be given to the stability of the burner manufacturer and that of his local distributor. The reputation of the burner in past performance is of equal importance. The simplicity and quality of the mechanical construction should be studied and the element of noise, must be given attention.

A burner listed as standard by the Underwriters' Laboratories, may be considered as having been built-up standards.

The problem of oil storage is relatively simple, since all the fuel may be stored in tanks buried outside. One-thousand gallon tanks of 3/16 in. steel seem to be most popular although the two and three thousand gallon sizes are coming into considerable favor. In estimating the size of storage tank it is well to remember that 170 gal. of oil is approximately equivalent to 1 ton of coal.

Inquiry should be made as to the available truck capacities before selecting tank sizes, as the tank should be large enough to accommodate an entire truck-load of oil, while still containing a "working balance."

Local ordinances should be strictly adhered to. Some cities require that a buried tank shall be at least 2 ft. beneath the surface of the ground and at least five feet from a building wall. Others provide that a line drawn at 45 degrees from the junction of the basement floor and the building wall, shall not touch the tank.

The tappings, 2½ in. fill, 1 in. vent and 1 in. oil suction, should all be in the top of the tank. Manholes, oil return lines and steam coils are unnecessary in tanks for the kind of oil suitable for residential work.

In the low-priced burners utilizing basement auxiliary tanks, such tanks should be at least 10 ft. from the nearest fire; they should be replenished by hand pumps connected to the main oil tank buried outside. Where no outside storage is provided, these auxiliary tanks should be filled and vented outside, and should also be provided with a tight-fitting, float gage, so that if the tanks are over-filled, there can be no spilling of oil in the basement.

CHAPTER XII

GAS HEATING

THE increase in the use of gas for house heating has been a great stimulus to the development of highly efficient gas burning appliances. Gas-burning heating installations as the sole source of heat for residences, factories, and public buildings (formerly limited to those localities where there was an abundant supply of cheap gas) are taking a more prominent place in coal-burning regions.

Gas-burning heating appliances present an opportunity for the realization of nearly ideal efficiencies in combustion and heat transmission. Full advantage must, however, be taken of the inherent efficiency of such appliances and every effort made to retain this efficiency, for it is only on this basis that gas can compete with coal.

TYPES OF GAS HEATING APPLIANCES

Gas-burning heating appliances may be classified as those for heating individual rooms; and central heating plants, heating an entire residence or other building. Each classification may be subdivided as follows:

1. Room Heaters
   - *a* Reflector Heaters (luminous flame)
   - *b* Radiant Heaters (blue flame)
   - *c* Gas Logs (blue flame)
   - *d* Tubular and Cylindrical Radiators
     - (a) Floor Furnaces
   - *e* Gas Fired Steam Radiators
     - (a) Bungalow type hot water systems

2. Central Heating plants
   - *a* Warm Air Furnaces
   - *b* Steam Heating plants
   - *c* Water Heating plants

COMBUSTION OF GAS

In the above classification it will be seen that some heaters are designated as *luminous flame* or *blue flame.* This distinction comes from the type of burner used. Gas burners are of two general types: Luminous flame burners, and the more widely used Bunsen or blue flame type. Each type of flame has its own field of usefulness; and if combustion is complete, and the flame properly applied, each will deliver the same amount of heat from a given quantity of gas. Gas requires for complete combustion air in the proportion of about 1 cu. ft. for each 110 B.t.u. of gross heat value. The two flames differ in the manner in which this air is supplied for combustion. If gas is forced directly into the atmosphere through a small hole, the air required for combustion is drawn into the

Material compiled for this chapter by W. E. Stark, engineer, Bryant Heater & Mfg. Co., Cleveland, O.

jet and the gas burns with a large yellow flame. As the holes in such burners must be small, appliances using them cannot burn gas in large quantities. A luminous gas flame must not be permitted to touch any cold solid surface as this will result in arrested or incomplete combustion, the deposit of soot and the formation of carbon monoxide.

Blue flame or Bunsen type burners are provided with an external mixer in which a portion of the air (about 2 cu. ft. per cubic foot of gas) is mixed with the gas previous to ignition. This is called primary air. The flame issuing from the port of the burner has two distinct parts: a pale blue inner cone and a darker cone surrounding it. The heat of the flame issuing from the burner port draws currents of air past the flame and into it in sufficient quantity to cause complete combustion. This is known as secondary air. The flame should sit squarely on the port and should not have a yellow tip. A yellow tip indicates insufficient primary air, and is corrected by opening the adjustable air shutter.

It should be noted here that the proportions of the orifice at the entrance to the burner tube, and the proportions of the burner ports must suit the heat content of the gas being burned. A burner proportioned for natural gas is not suitable for water gas or coal gas, which are much bulkier in relation to their heat contents.

Table 83 shows the heat values of a cubic foot of gas and air mixture, the gas being mixed with the amount of air theoretically required to burn it. In practice excess air must be admitted to the fire in order to insure complete combustion.

TABLE 83. VOLUME OF AIR REQUIRED FOR COMBUSTION OF DIFFERENT GASES*

GAS	B.T.U. PER CUBIC FOOT	CU. FT. AIR TO BURN CU. FT. GAS	B.T.U. PER CU. FT. OF MIXTURE
Natural Gas	1084	10.27	96.2
Coal Gas—Rich	580	5.21	93.4
Coal Gas—Lean	510	4.43	93.9
Carburetted Water Gas	575	5.02	95.5

*Thomas King. *American Gas Journal*, October 22, 1921.

HEAT VALUE AND EFFICIENCY

A gas may be said to have two heat values; a gross or *higher* heat value and a net or *lower* heat value. The higher heat value is the entire heat that is liberated by the gas when it is burned completely. The complete combustion of a gas results in the formation of water vapor; the amount depending on the proportion of hydrogen or hydrocarbons in the gas. In order to utilize completely all of the heat of combustion of the gas it would be necessary to condense the water vapor in the products of combustion; thus reclaiming its latent heat of vaporization, and then to cool down the water to the starting temperature.

To condense any of the water vapor in the products of combustion it is necessary to cool them down to the dewpoint, which will always be below 212 deg. This is what is done in a calorimeter, but it is obviously impossible to do it in any commercial gas-burning appliance. Since it is not

possible to utilize all of the heat liberated by the gas in burning, the heat value is sometimes expressed in terms of the lower value; obtained by deducting from the higher value, the total heat of the water vapor down to the starting temperature. The lower heat value is always about 10 per cent less than the higher heat value.

Although it is practically impossible to utilize the higher heat value in any house heating appliance, it is nevertheless customary to express boiler and furnace efficiencies in terms of this higher value. This gives a lower efficiency than one calculated from the lower heat value and is of course based on an unattainable standard, but it is a more accurate and consistent way of expressing efficiencies. An appliance may reclaim a little bit of the latent heat of the water vapor. If the test efficiency of such an appliance is calculated from the lower heat value, one is placed in the position of crediting the appliance with some heat that was not charged against it. Although quoted efficiencies are usually based on the higher heat value, care should always be taken to understand which standard guaranteed efficiencies are based on.

For example.—Take an hypothetical gas having a gross heat value of 550 B.t.u. per cu. ft. and a net heat value of 500 B.t.u. per cu. ft., burned in a steam boiler giving an evaporation of 465 lb. of water (from and at 212 deg.) per 1000 cu. ft. of gas burned:

$$\text{Efficiency} = \frac{\text{B.t.u. in steam}}{\text{B.t.u. in gas}} \times 100 = \frac{465 \times 970.4}{\text{cu. ft.} \times \text{heat value}} \times 100$$

$$\text{With Gross Value Efficiency} = \frac{451{,}235}{550{,}000} \times 100 = 82.04 \text{ per cent}$$

$$\text{With Net Value Efficiency} = \frac{451{,}235}{500{,}000} \times 100 = 90.25 \text{ per cent}$$

It will be noted from the example cited that when the efficiency is based on the net or lower heat value, the appliance apparently absorbs 8.21 per cent more of the heat supplied to it than when the efficiency is based on the gross heat value.

The following Table 84 shows the maximum possible efficiencies obtainable when burning a typical manufactured gas with various stack temperatures. These are based on the gross heat value and do not include any

TABLE 84. PRODUCTS OF COMBUSTION AND EFFICIENCIES WITH TYPICAL MANUFACTURED GAS

Stack Temperature (deg. fahr.)	220	235	250	265	280
Heat in Dry Flue Gas above 60° (%)	3.25	3.57	3.90	4.14	4.28
Heat in Water Vapor above 60° (%)	9.95	10.03	10.10	10.16	10.22
Heat absorbed by Boiler or Efficiency (%)	86.80	86.40	86.00	85.70	85.50
	100.00	100.00	100.00	100.00	100.00

Flue Gas Analysis

CO_2 8.04% O_2 5.86% N_2 86.10%

correction for radiation from the boiler covering. Radiation would reduce these efficiencies from 2 to 10 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	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., 580 B.t.u.
O_2	0.1 " "	Specific gravity 0.418 (air = 1)
CO_2	1.5 " "	Air Temperature 60 deg. fahr.
N_2	3.5 " "	Atmospheric moisture neglected.
	100.0	

TYPES OF GAS HEATERS

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. The flame must never be so long that it strikes any part of the heater.

Radiant Heaters have a blue flame which heats refractory "radiants" or "glowers" to incandescence. Radiant heaters are quite sensitive to changes in gas pressure. The radiants should not glow more than two thirds of their height if the products of combustion are to be free from carbon monoxide gas and in no case should flame issue from tops of the radiants. These heaters operate best if the gas pressure at the orifice is left constant, regulation being secured by an adjustment at the orifice and not by a cock in the gas line.

Gas Logs have a very poor efficiency if they are placed in a vented fire place, as the radiating power of a blue flame is low and most of the heat goes up the flue.

Tubular and Cylindrical Radiators give off their heat by radiation from black sheet iron covers, similar to old style coal stoves. They are also made in the shape of a steam radiator, either cast iron or pressed steel being used.

Floor Furnaces heat by convection, being placed directly beneath floors and heating the room above by the currents of air set up through the heater. They discharge products of combustion into the heated room.

Gas-Fired Steam Radiators permit local heating with close automatic control, without the extremely intense heat that is present when the gas gives up its heat directly to the radiating surface.

VENTING

It is always safest to vent individual room heaters to an unobstructed chimney. Then no danger can arise from the flame flashing back into the mixer due to low pressure, or from a sudden increase of pressure above that for which the appliance is adjusted. If the gas pressure is certain and constant and if the burner adjustment is correct such appliances are often vented into ventilated rooms and are considered reasonably safe. In no case, however, should unvented heaters be used in sleeping rooms.

CENTRAL HEATING PLANTS

Individual room heaters are suitable only for taking the chill off in mild weather; or, in the case of a house heated with a coal boiler or furnace, for warming up a room quickly, while the more sluggish coal burning appliance is getting under way. Central heating with gas offers the opportunity to secure uniform temperature throughout the house and instant response to the wishes of the owner, without a multiplicity of controls and vents.

Gas can be burned efficiently in warm air furnaces designed for the purpose. The principal requirements in the design of such furnaces are: a path for the hot gas that can be traversed with very little draft loss, thus permitting maintenance of sufficient draft with a low flue gas temperature; and sufficient surface to insure the transmission of most of the heat by direct contact with the hot gases, as a gas flame gives off very little radiant heat.

The heating surface can be placed very close to the burner as combustion is complete within a short distance from the burner. The use of gas in a coal furnace is unsatisfactory at best.

Gas-fired boilers, designed for gas, give very high efficiences, 80 per cent (based on gross heat value) being readily obtainable. A properly designed and installed steam boiler should operate at full rating without priming and with a stack temperature not over 50 degrees higher than steam temperature. Gas boilers can be applied to any type of steam or hot water heating system. To obtain fully the benefits to be realized from the inherent efficiency of the gas boiler, certain precautions should be observed in installation.

Adequate provision should be made for venting air from the system. A gas burning boiler has very little heat storage capacity. As soon as the fuel is turned off by the controlling devices, cooling starts and inleakage of air begins in greater or less degree. When heat is again demanded this air must be purged from the system by the steam before heating can begin. Unless the system rids itself of air easily, there will be a "sawtooth" effect on the temperature; caused by the house cooling below the temperature for which the thermostat is set, before steam can expel the air and reach the heating surfaces.

A gas-burning boiler lends itself readily to automatic control and such control should be used; since it is a decided aid to economy. Room temperature control on steam boilers and dual control of both room and water temperatures on water boilers should be installed. Steam boilers should be equipped with a steam pressure regulator and with a low-water fuel cut-off; and all boilers should be provided with gas pressure regulators. All of these devices are standard equipment on most gas boilers.

Like a boiler using any other fuel, a gas boiler requires adequate provision for venting. The products of combustion are colorless and odorless; but they are none the less tangible, and the chimney must provide sufficient draft to carry them away. Since a gas boiler operates satisfactorily with very little draft tension, it is advisable to install some kind of draft check between the boiler and the chimney. This serves the double purpose of keeping the chimney draft low so that the heat lost to

the stack will not be excessive and of protecting the pilot flame against back-drafts. The boiler manufacturer generally furnishes a satisfactory device as part of the standard equipment.

The problem of installing a gas-fired warm-air furnace is not greatly different from that of installing a coal-fired furnace. Warm air pipes and registers should be liberally proportioned (see Chap. X, p. 143) so as not to obstruct the free flow of large amounts of air; and recirculation should always be practiced. Thermostatic control should of course be employed. Dual control, that is, control of both room temperature and duct temperature, is becoming popular. It makes for more even heating and provides a sure safeguard against overheating arising from registers being closed while the furnace is in operation.

On account of their small heat storage capacity, gas boilers are particularly adaptable to extremely low pressure (vapor) steam heating systems. The small water capacity and quick steaming ability insure instant response to the sensitive steam pressure regulators.

RATINGS

Gas appliance manufacturers have followed the custom established by coal appliance manufacturers in rating their product in terms of cubic feet of warm air and square feet of steam or water radiation. The capacity of a gas furnace or boiler is subject to smaller fluctuations than a boiler employing solid fuel and the element of length of firing period does not enter into consideration. Gas appliance manufacturers rate their boilers in terms comparable with the usual 8-hour rating of coal boilers. In other words, where a 2400 sq. ft. coal boiler would be chosen, a 2400 sq. ft. gas boiler would generally be appropriate.

It is common practice for gas boiler manufacturers also to rate their boilers in terms of *Available B.t.u. per hour.* To use this rating the calculated heat loss from the building is increased by the usual percentage allowed for piping losses and the appropriate boiler chosen.

A gas furnace or boiler will show essentially the same capacity or efficiency with any gas fuel, provided steps are taken to furnish burner equipment and air regulation appropriate to the fuel burned. Most manufactured gases, although of lower heating value than natural gases, if burned in sufficient volume will produce equivalent results. The heating value of a mixture of gas and air (air just sufficient to burn the gas completely) is almost the same for any typical commercial gas, as is shown in Table 83.

It is a fact, based upon observation, that the user of a gas-fired central heating appliance 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 and is left in operation on many days when very little heat is required to keep the inside temperature at 70 to 72 deg.; days when it would be impracticable 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.

A great deal of data is available covering the fuel requirements of steam and hot-water heating systems. Not a great deal is available on warm-air furnace systems, consequently no effort will be made to present any.

In making an estimate of the gas that will be consumed by a gas-fired boiler during the average heating season, two variables must be taken into account. The first 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 unit adopted by the *American Gas Association.* 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 85, giving values of degree days for several representative cities:

TABLE 85. DURATION OF HEATING SEASON

City	Degree—Days for Heating Season	City	Degree—Days for Heating Season	City	Degree—Days for Heating Season
Atlanta	2880	Denver	5880	Pittsburgh	5327
Boston	6055	Detroit	6202	San Francisco	3450
Buffalo	6750	Jacksonville	1080	St. Louis	4583
Cincinnati	5302	Kansas City	5302	Philadelphia	4950
Cleveland	6096	Minneapolis	7953	Seattle	5156
Chicago	6007	New York	5303	Washington	4562
Dallas	2455	Oklahoma City	3827		

By averaging the records of a large number of gas-boiler installations, the following equations have been derived:

$$\text{For Steam } G = \frac{102 \times R \times D}{H} \qquad \text{For Water } G = \frac{59 \times R \times D}{H}$$

where G = cubic feet of gas per season
R = square feet of direct cast-iron radiation
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 300 sq. ft. steam heating system in Chicago.

From Table 85 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 cu. ft. Substituting in the equation:

$$G = \frac{102 \times 300 \times 6007}{535} = 343{,}578 \text{ cu. ft.}$$

The requirements of individual installations may vary considerably from an average of several. Generally stores, offices, factories, and other commercial buildings require less heat per season than do residential buildings provided with an equal amount of radiation.

In coal furnaces or boilers, the path traveled by the hot gases is relatively short and the surface with which they come in contact is relatively small as compared to gas heating apparatus. A large proportion of the heat in the coal is given off by the incandescent fuel bed as radiant heat. As a gas flame radiates very little heat, the hot products of combustion must come in direct contact with the heating surfaces. For this reason the use of gas in coal-burning appliances is always wasteful

and about three times as much gas will be required than if it were burned in a properly designed appliance. The gas-burning appliances have a longer fire travel and more heating surface than those burning coal and can therefore absorb more heat from the hot products of combustion in a given time.

Coal-burning boilers are constructed with large passages for the flue gas so that the draft loss through them can be kept as small as possible, thus permitting most of the chimney draft to be exerted in drawing the air through the fuel bed. When gas is burned under a boiler with such liberal passages, the draft becomes too great and the stack losses become excessive. A boiler designed for gas can have restricted passages for the products of combustion, permitting them to come into very intimate contact with the heating surfaces. The experiences of the gas companies in several large cities with conversions have been such as to discourage their use.

Warm air furnaces, designed for use with manufactured or natural gas, are available in sizes ranging from 5000 to 20,000 cu. ft. rated capacity. House-heating boilers, of the cast iron sectional type, designed especially for gas fuel, are available in single units ranging from 200 to 7500 sq. ft. of equivalent direct radiation.

CROSS-CONNECTING COAL AND GAS BOILERS

Quite frequently, when a customer has already a coal boiler in his home, it is desirable to leave the coal boiler in place, and to cross-connect the gas boiler with it. For small gas companies or any others where there is any possible chance of a shortage or failure of gas, it would seem to be good practice to encourage cross-connecting as the customer would realize very little for a second-hand coal boiler, and it is worth more to him as a safeguard against failure of his gas system than he would realize by selling it. It also 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. There is almost no difference in the cost of an installation, whether it is cross-connected or displaced. Cross-connection also gives the customer a means of disposing of papers, crating and other waste material.

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 installation, it is necessary to valve off all of 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.

CHAPTER XIII

AUTOMATIC HEAT CONTROL

TEMPERATURE regulation is a vital function in the human body. We all carry about with us remarkably effective automatic heat control equipment. 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 an economy.

All heating apparatuses 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. 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 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 control, not only for economy and satisfaction, but also to prevent scalding the bodies of users.

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

Compiled especially for THE GUIDE by Samuel R. Lewis, consulting engineer, Chicago, Ill.

sufficient energy from the thermostat itself. This class of apparatus is especially adpated 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. 60, 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

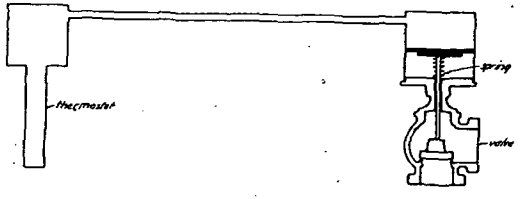


FIG. 60. EXAMPLE OF UNIT TYPE THERMOSTAT

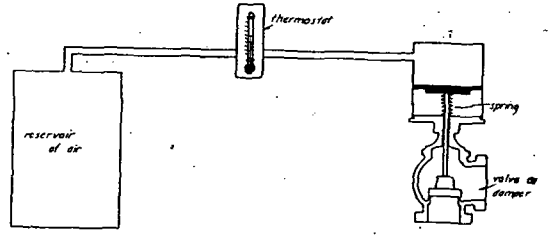


FIG. 61. EXAMPLE OF THERMOSTAT USING OUTSIDE POWER

Note.—When thermostat opens, air passes from reservoir and closes valve. When thermostat closes, air between thermostat and valve is released and spring opens valve.

operation manually of distant dampers and valves. Pilot type thermostats 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 HEAT CONTROL

New uses and styles are developed daily. Some of the applications will be listed which are believed to be approved methods of installation.

Tempering Heaters

The tempering heaters, particularly if they are of copper with extended surfaces, and there is a two-pipe vacuum system of steam circulation having a vacuum pump, should be 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 an outside thermostat set to shut off steam when the outside temperature reaches around 34 deg., and to keep steam turned on when the outside temperature is cooler than 34 deg. There should be an additional layer of tempering heater, controlled by an additional thermostat in the duct beyond the fan, where mixing of the strata of air has 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 beyond the fan. It is never permissible to use a by-pass damper around a tempering heater in front of an air washer.

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,

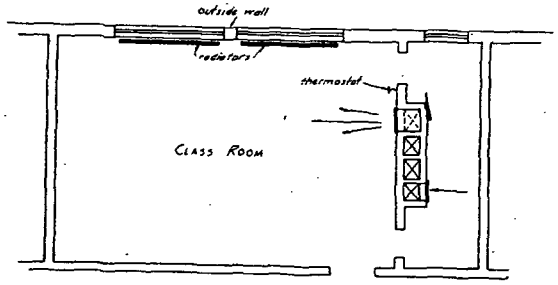


FIG. 62. PLAN OF CLASS-ROOM IN AN ELEMENTARY SCHOOL, SHOWING LOCATION OF THERMOSTAT

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

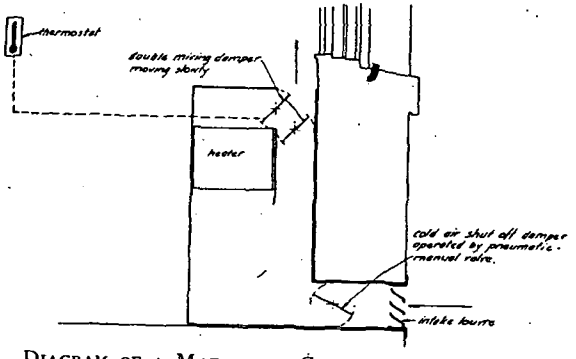


FIG. 63. DIAGRAM OF A METHOD OF CONTROL FOR A UNIT VENTILATOR

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 Ventilating 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. It is usually not wise to operate the steam supply valves with thermostats, since freezing may occur, and it is usually not practicable to install in these units separate tempering heaters with separate automatic control. 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 circulation 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

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 latter should be subjected to unfair exposure such as an open window.

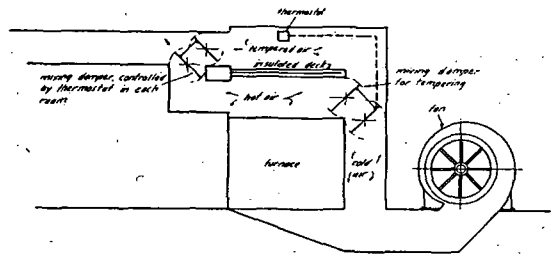


FIG. 64. AN ARRANGEMENT FOR TEMPERED AIR WITH WARM AIR FURNACES

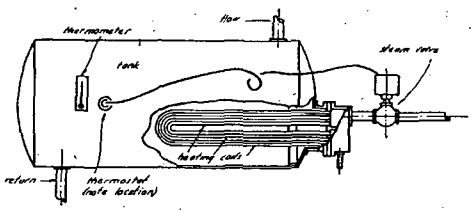


FIG. 65. STEAM HEATED SERVICE WATER HEATER

Warm-Air Heating

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 Heating

It is safe to say that no service hot-water heater should ever be installed without automatic heat control. 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

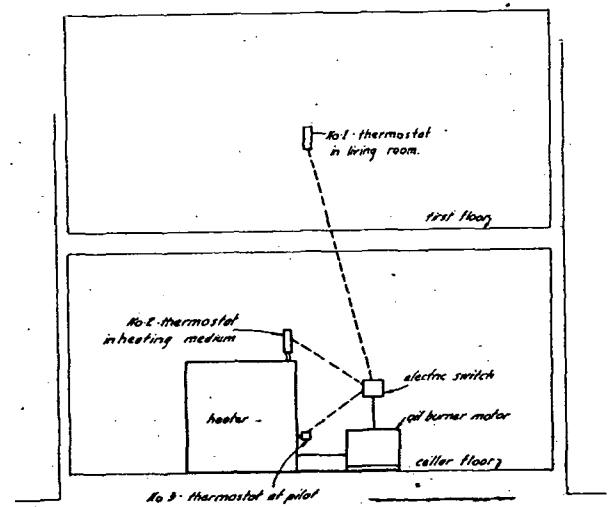


FIG. 66. TYPICAL ARRANGEMENT FOR OIL BURNER

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. An additional 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. An additional 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 Burner Control

The same high intensity as with oil fuel makes it necessary to depend on thermostats to prevent waste, and the intermittent operation and 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.

DOUBLE THERMOSTATIC CONTROL

Nearly all buildings equipped with a large number of thermostats and using compressed air for power, are occupied only part of each 24 hours, and can without any prejudice be kept at a lower temperature during unoccupied periods, as over night or over a holiday. The conventional thermostats as ordinarily applied militate against this arbitrary reduction, and each instrument would have to be adjusted each time for the lower degree, and then each would have to be restored following the unoccupied period. Equipment is available which provides two temperature adjustments to each instrument, such that if the general air pressure leading from the central compressor to the thermostat is suddenly changed, the service is switched automatically from one control to the other, and if the pressure again shall be suddenly changed, the service will be switched back. Thus at 6 o'clock P. M., say, the engineer of an office building releases the air pressure for an instant and all of the thermostats are switched from the 68 deg. control to the 45 deg. control. Either control, of course, is set for any temperature desired. At say 7 o'clock the following morning, a repetition of the drop in air pressure will restore to service the 68 deg. temperature.

In a school building the compressed air supply mains may be grouped so that parts of the building used for night school only remain on the 68 deg. service, while others can be thrown over to the alternate service and kept much cooler until again required for occupancy.

A familiar scheme similar to the foregoing, with a cooler temperature automatically maintained during the night and increased early in the morning is in use, with the switch operated by a clock, for residence work.

Central Station Heating

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, as it automatically varies the steam pressure in the radiating surface within a considerable range, giving excellent regulation as well as economy.

Automobile Engine Control

The importance of thermostatic regulation of the cylinder temperature of internal combustion engines has long been recognized, but until comparatively recent developments in the production of thermostats, has been ignored in practice.

Now the majority of automobiles are provided with thermostats in the cooling medium controlling the volume of air passing the radiator by means of shutters. Several widely advertised and highly developed makes have thermostatic control of valves in the circulating medium.

AUTOMATIC HEAT CONTROL IN INDUSTRY

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. A thermostat is a necessary equipment with each automatic refrigerating machine.

CHAPTER XIV

INSULATION FOR PIPING AND BUILDINGS

THE economic value of insulation on heated surfaces such as steam and hot water pipes, boilers, furnaces, ovens, etc., has been fully recognized and now increased attention is being given to the value of insulation in building construction; therefore, data on this subject have been included in this chapter.

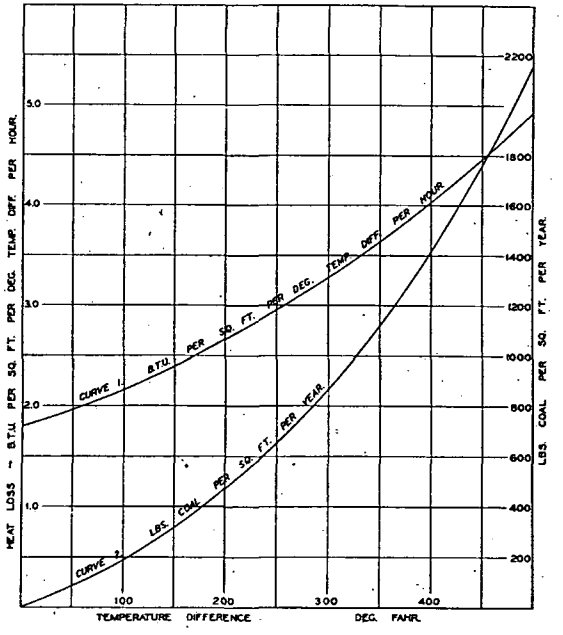


FIG. 67. HEAT LOSSES FROM BARE SURFACES

LOSSES FROM BARE HEATED SURFACES

The first consideration in determining whether or not pipes and other heated surfaces should be insulated is the magnitude of these losses from such surfaces if they were allowed to remain bare. Fig 67 shows the rate of bare surface losses under still air conditions in B.t.u. per square foot

Compiled especially for THE GUIDE by L. B. McMillan, New York, N. Y.

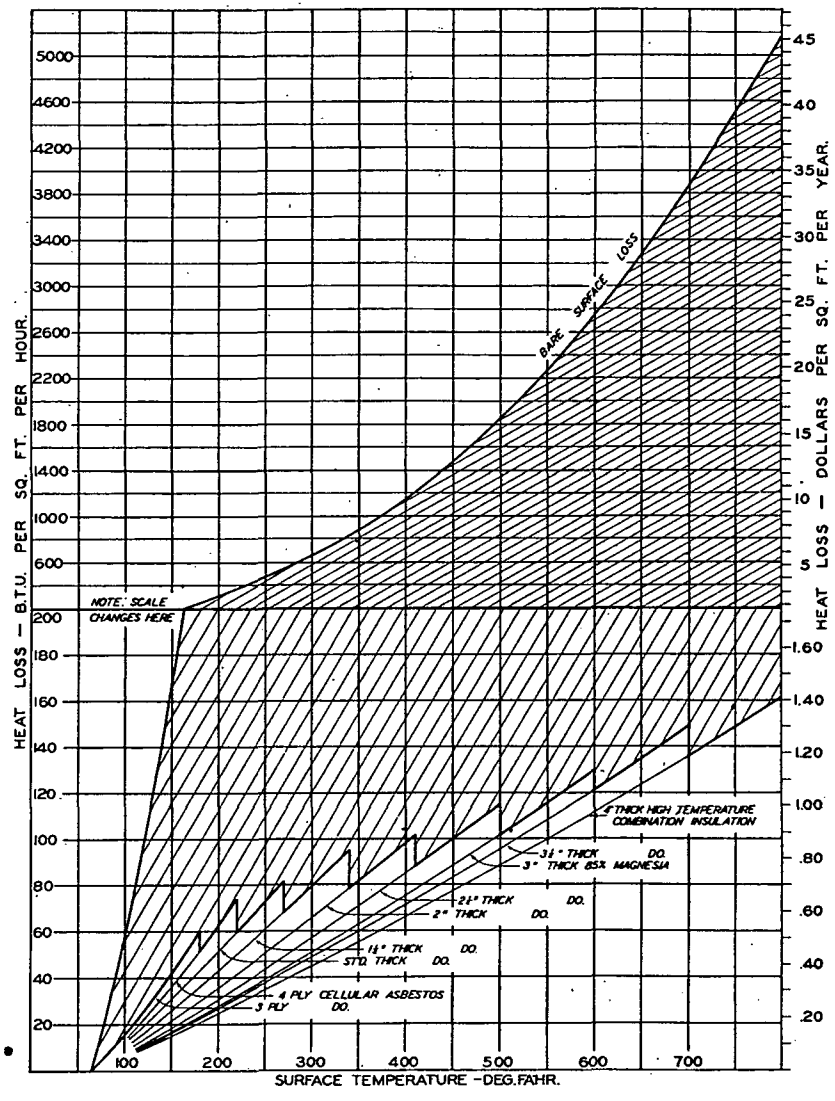


FIG. 68. LOSSES FROM APPROPRIATELY INSULATED SURFACES AS COMPARED WITH LOSSES FROM BARE SURFACES

Note.—The scale showing Dollars loss per sq. ft. per year is based on a unit cost of $1.00 per 1,000,000 B.t.u. *The actual cost is usually less than this* where heat is derived directly from burning coal or oil, but may be greater where illuminating gas or electricity is the source of heat. However, the use of $1.00 as the unit greatly simplifies the use of the chart in connection with any cost per 1,000,000 available B.t.u. All that is necessary is to multiply the values from the chart by the ratio of the actual cost to $1.00. For example, if the cost of heat is $.50 per 1,000,000 B.t.u., multiply values from the chart in dollars by 0.5, etc.

per degree temperature difference per hour (Curve 1, TRANS. A. S. H. & V. E., Vol. 26, P. 368) and the total losses in pounds of coal per year (Curve 2). The latter is based on 10,000 B.t.u. available per pound of coal and 8760 hours per year. Where surfaces are not heated for entire year, losses for actual period of operation may readily be obtained by multiplying values taken from Curve 2 by the appropriate proportion. This also applies to the losses in dollars per year shown in Fig. 68.

HEAT LOSSES FROM INSULATED SURFACES

Fig. 68 shows the losses from appropriately insulated surfaces compared with losses from bare surfaces. It will be noted that it was necessary to plot the upper part of the bare surface curve to a greatly reduced scale in order to show it on the same sheet with the curves for losses through insulation. Therefore, for a true measure of the relative losses from bare and insulated surfaces, compare the numerical value of the ordinates of the curves rather than the apparent spaces between the curves on the chart.

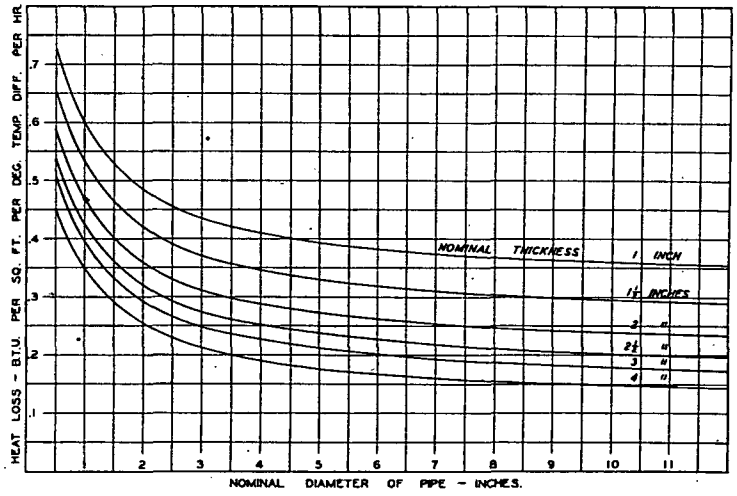


FIG. 69. VARIATION WITH PIPE SIZE OF RATE OF HEAT TRANSMISSION THROUGH A GIVEN THICKNESS OF INSULATION

The chart, Fig. 68, is based on still air conditions, room temperature of 70 deg. fahr., and 5 in. pipe size. The effect of pipe size on losses through insulations of various thicknesses is shown in Fig. 69. (TRANS. A. S. H. & V. E., Vol. 26, p. 375).

For equations by means of which heat losses may be calculated for any thickness of insulation on any pipe size see TRANS. A. S. H. & V. E., Vol. 26, p. 360. Refer also to manufacturers' data for heat losses and efficiencies of different insulations on various sizes of pipes.

RADIATING SURFACE OF PIPES

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 86 gives these areas for various standard pipe sizes.

CONDUCTIVITIES OF INSULATING MATERIALS

The conductivities, in B.t.u. per square foot per hour per inch thick per degree fahr. temperature difference, of various insulating materials are given in Table 87. It should be emphasized that in this table all variables due to differences in thickness, different pipe sizes, and different air conditions, are eliminated.

TABLE 86. 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

TABLE 87. CONDUCTIVITIES OF VARIOUS INSULATING MATERIALS

	Conductivity	Temp. Diff. at which Conductivity was Determined Deg. Fahr.	Authority	Year
Asbestos-Sponge Felted	0.468	300	*Trans. A. S. M. E.*, Vol. 37, p. 968	1915
Wool Felt	0.521	300	"	1915
85% Magnesia	0.54	300	*Trans. A. S. M. E.*, Vol. 40, p. 667	1918
Carocel	0.54	300	*Trans. A. S. M. E.*, Vol. 37, p. 968	1915
Nonpareil H. P.	0.543	300	"	1915
Plastic, 85% Magnesia	0.587	300	"	1915
Asbestocel	0.596	300	"	1915
Expanded Asbestos	0.598	300	"	1915
Indented	0.686	300	"	1915
Molded Asbestos	0.778	300	"	1915
Air Cell	0.802	300	"	1915
Vitribestos	1.087	300	"	1915
Asbestos Fire Belt	1.093	300	"	1915
Corkboard	0.304	36	TRANS. A. S. H. & V. E., Vol. 26, p. 406	1920
Hair Felt	0.246	36	"	1920

TABLE 88. PROPER THICKNESS OF INSULATIONS FOR MAXIMUM NET SAVING

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.

ECONOMICAL THICKNESS OF INSULATION

Table 88 (TRANS. A. S. H. & V. E., Vol. 26, p. 377) shows the thicknesses of insulation which will give most economical results under average conditions.

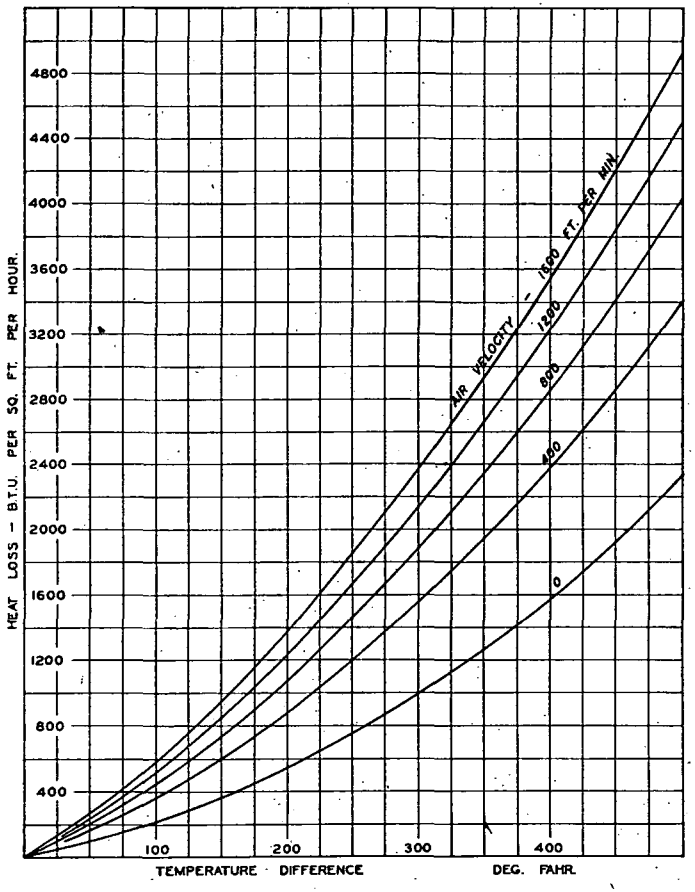


FIG. 70. HEAT LOSSES FROM SURFACES EXPOSED TO VARIOUS AIR VELOCITIES

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. 70 (*Iron & Steel Engineer*, July, 1925), 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.

EFFECT OF AIR VELOCITY ON LOSSES FROM INSULATED SURFACES

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 heat 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 crevasses 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 weatherproof jacket, and other outdoor insulation should be thoroughly weatherproofed.

HEATING CONDUITS

When steam pipes are run between buildings they should be placed in some form of waterproof conduit which will withstand earth loads and take care of the expansion and contraction of the piping without strain or stress on the couplings, and without affecting the insulation 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. The anchors used are usually U-shaped steel straps which partially encircle the pipes and are firmly bolted to a short length of structural steel set in concrete.

TEN IMPORTANT POINTS ABOUT INSTALLATION

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 or bend must 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 less than 150 ft. 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 less than 250 ft. 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 500 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 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 bend.

10. A proper hydrostatic test should be applied to the piping before top of 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.

STYLES AND CONSTRUCTION OF CONDUITS COMMONLY USED

Filler Type.—The pipes are supported on rollers placed on a steel rod which rests on an iron frame. The frame is set on a concrete or mortar 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 existing sewers led to some other point of free discharge.

Insulated Tile Type.—The insulating material, which is diatomaceous earth, is molded to the inside of a split tile conduit. The pipes are supported on rollers, which in turn are supported by an iron frame which extends through the conduit and rests on a tile base which also serves as an underdrain. 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 jacket of standard asphalt waterproof roofing 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).—In 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 roll 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.

Wooden Conduit.—Each pipe is enclosed in a tin-lined wooden casing. Sufficient space is allowed between the pipe and the casing to provide for the insertion of pipe guides or rollers which rest on the bottom of the casing. The casings are bedded in gravel or broken stone and one or more tile underdrains are laid beneath them.

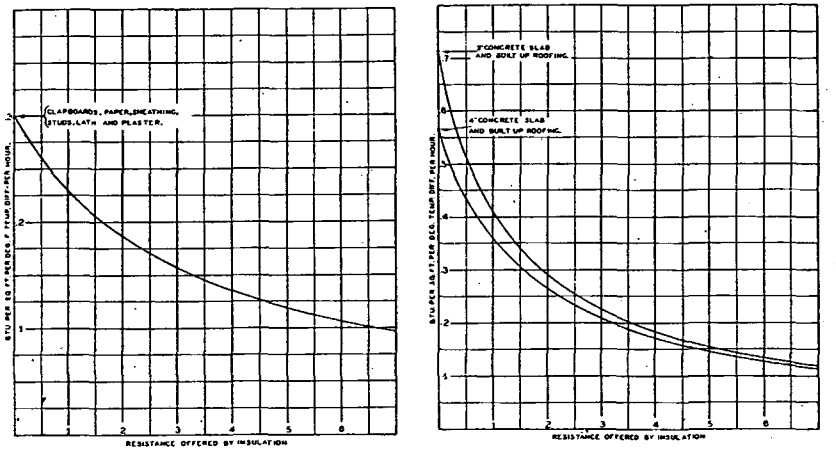
BUILDING INSULATION

Through the use of insulating materials in building construction, the losses through such constructions are greatly decreased; therefore, the saving in fuel, also the effect on the heating equipment required are of considerable interest.

Fig. 71, section A shows the reduction in heat losses through frame building construction, due to insulation of various degrees of effectiveness. The topmost point on the curve represents the rate of heat loss through construction consisting of clapboards, paper, sheating, studs, lath and plaster, but without insulation. If insulation is used in addition to the construction outlined, the rate of heat loss through the entire wall is given by the ordinate of the curve at the point on the horizontal scale

corresponding to the resistance of the insulation added. The curve may therefore be used in connection with any insulating material by determining its resistance for the thickness under consideration. In the accompanying tabulation are given the resistances per 1 in. thick of several well known materials. For thicknesses other than 1 in., multiply the value from the table by the thickness in inches. (In case the insulation completely fills the space between the studs, so that there is no air space, subtract 1.0 from the total resistance so obtained, conversely when the insulation is so placed as to provide an additional air space, add 1.0 to the total resistance.)

Insulation of frame building walls often produces a greater reduction in heat losses than the estimated values because of the increased tightness of the construction against air leakage.



A—Frame Building Walls B—Concrete Roof Slabs

FIG. 71. EFFECT OF INSULATION IN REDUCING HEAT LOSSES THROUGH WALLS AND ROOFS

ROOF INSULATION

Fig. 71, section B shows the effect of insulation in reducing the losses through concrete roof slabs. The topmost point on each curve represents the rate of heat loss through the given thickness of slab, with built-up roof, but without insulation. In order to determine the rate of loss through the roof construction, when any given thickness of insulation is added, determine the resistance of the insulation by multiplying the resistance per 1 in. thick, by the thickness in inches. The ordinate of the curve at the point on the horizontal scale, corresponding to the resistance so determined, gives the rate of heat loss through the entire construction.

In addition to reducing the fuel and heating equipment requirements, one of the most important functions of roof insulation is that it greatly reduces the temperature differential between the lower side of the roof

slab and the air of the room. Therefore, by maintaining the temperature of the surface above the dew point of the air in the room, insulation is very effective in correcting condensation troubles.

INSULATION RESISTANCES OF VARIOUS BUILDING INSULATIONS

MATERIAL	RESISTANCE PER 1" THICK
Keystone Hairfelt	3.69
Cork	3.24
Cabot's Quilt	3.12
Flaxlinum	3.04
Fibrofelt	3.04
Celotex	2.67
Lith Board	2.64
Insulex—12 lb. per cu. ft.	2.5
Insulex—20 lb. per cu. ft.	1.6

PART II

CHAPTER XV

VENTILATION

VENTILATION is the science which has to do with the maintenance of such indoor air conditions as are most conducive to proper health and comfort. Practical ventilation results may mean anything from the very best to the very poorest in quality and from the maximum to nothing in quantity. Ventilation perfection is, however, a very definite thing which may be defined as follows:

That atmospheric condition in every part of indoor space occupied by human beings which is continually maintained with a proper amount of oxygen; free from dust, bacteria, objectionable odors, poisonous and other objectionable substances; with suitable air movements and at the temperature and humidity quality shown within the zone of human comfort as defined by the joint research work of the AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS, the United States Bureau of Mines and the United States Public Health Service.

Taking this as the highest aim of ventilation and calling it 100 per cent the other extreme of 0 per cent of ventilation may be defined as follows:

That atmospheric condition in any part of indoor space occupied by human beings where one or more of the above enumerated factors is or are maintained so as to separately or collectively inflict death or permanent injury upon human beings.

Between these two extremes are the wide range of conditions met with in practice.

Good ventilation may be defined as follows:

That percentage of perfection of the above factors which is warranted by the requirements of human health, comfort and efficiency on the one hand and expense and labor to produce these conditions (wherever they do not naturally exist) on the other.

The science of ventilation began its existence with, and is still growing out of, the fact that wherever human beings assemble within an enclosed space the atmosphere within this space will become vitiated, unless proper provisions are made to prevent it. It is the difficulty of determining and applying these proper provisions of prevention that has kept physiologist and ventilating engineers busy for so many years endeavoring to produce something like satisfactory results.

The commonly accepted usage of the term *vitiated atmosphere* has for a long time continued to designate conditions which cause unpleasant, uncomfortable or unhealthful physiological reactions, but our interpretations of the true causes and meanings of these reactions have undergone many vital changes with the progress of the art and our growth in its knowledge.

Compiled especially for THE GUIDE by Perry West, consulting engineer, Newark, N. J.

In other words the physiological effects of poor ventilation have continued to manifest themselves in much the same way but our knowledge of these manifestations are continually changing.

Among the effects, which have received the greatest amount of study and which are now generally recognized as direct results of poor ventilation, are the following: Drowsiness, headache, loss of physical vitality, feeling of suffocation, temperature discomfort, brain fag, irritation of the membranes of throat, nose and lungs, infection, drying and cracking of and the causing of unnatural discharges from these membranes, disagreeable odors, loss of appetite, nervousness and general nausea.

OLD VENTILATION THEORIES DISCARDED

It is only within the last 20 years that all of these manifestations of poor ventilation have been definitely recognized and the present era of ventilation started. Prior to this time practically all artificial ventilation was attempted on what might be termed a quantity basis. This, on the theory that the carbon dioxide exhaled by persons in an occupied space was the primary cause of such of these manifestations as were then recognized. As a result of this theory it was believed that the all important thing about ventilation was the quantity of air necessary to be brought in from the outside in order to maintain an atmosphere containing not more than 10 parts of carbon dioxide per 10,000 parts, by volume, within any properly ventilated space.

This, as the basic theory of artificial ventilation, has long been deposed and discredited among engineers, scientists and physiologists, but there are those who still cling to this theory, either in its original form or in one of its many modifications. When it was first learned that the quantity of carbon dioxide ordinarily found in even poorly ventilated spaces could not, of itself, be entirely responsible for the unsatisfactory conditions met with under such circumstances, the possibility of other causes began to be seriously investigated. There followed a period in which it was believed that some form of poisonous effluvia was exhaled with the human breath and that this was responsible for the vitiation of the atmosphere within spaces occupied by human beings.

Later this idea was disproven and then it was believed that something might be excreted from the pores of the skin or that small particles might be given off from the body or the internal membranes so that the atmosphere became thus contaminated with matter, which upon decomposition formed toxins or poisons to cause the effects noted. This rather fanciful theory was soon discredited, however, and then began the real study of the subject which has finally brought the conclusions upon which work is now being done.

QUALITY VS. QUANTITY

It may be noted here that the basic idea of ventilation today is quality rather than quantity, or the proper conditioning and distributing of a small quantity of air by efficient compact means rather than the poor conditioning and poor distributing of larger quantities with apparatus too cumbersome and expensive to be kept in operation.

THE PRESENT STATUS OF VENTILATION

The result of all of this has brought us down to the present status of the art where it is no longer felt that the chemical composition of the air is the important factor but that proper ventilation depends more largely upon a number of other factors which may be stated in the order of their importance as follows:

1. Air Supply
2. Air Temperature
3. Air Cleanliness in reference to its freedom from dust and other suspended matter
4. Air Sanitation with reference to its freedom from bacteria
5. Relative Humidity
6. Distribution
7. Air Motion
8. Freedom from odors
9. Freedom from other injurious substances.
10. Freedom from monotony, with reference to noise and too much regularity of indoor conditions

Air supply is still put at the head of the list for the simple reason that while this is no longer considered to be the all important factor in ventilation the amount of air to be supplied per person or the number of air changes to be furnished for any particular space will always be the starting point, for without air supply there can be no artificial ventilation.

The air supply is so vitally effected by the other factors mentioned that it cannot be determined independently and it will be seen that while this item is placed at the head of the list for the reason that it is the natural vehicle upon which the structures is carried, its importance beyond this point becomes subordinate to these other factors.

Air temperature is second for the reason that it has been proven by practically all of the accredited experimenters that over-heating is more detrimental to the quality of ventilation than any other one thing.

Air cleanliness is third for the reason that it has to do with human health both from the standpoint of freedom from dust and other suspended substances, which irritate and clog the air passages, and from the standpoint of freedom from bacteria and other infectious media carried along with these substances which constitute the dirt in air.

Air sanitation is fourth as it also has to do with human health and is correlated with the third item.

Relative humidity is fifth, not because it is of so much less importance than air supply and temperature but because it also bears such an intimate relationship with these two items that it receives a part of its due consideration in their determination. This will be further referred to in connection with air supply and air temperature in connection with which other factors are involved.

Distribution is sixth for a similar reason, for while it occupies a much more important place than this position might indicate, it is so closely allied with the effective air supply that it receives a part of its consideration therewith.

Air motion is seventh in the same way, as it too receives a certain amount of its consideration in connection with effective temperature.

Freedom from odors is eighth for the reason that while odors may become quite disagreeable and even nauseating they are seldom dangerous or permanently detrimental to health.

Freedom from other injurious substances is ninth, not because this might not be of more importance but because these substances are met with so seldom in ordinary ventilating practice and must be practically eliminated in any case.

Freedom from monotony is tenth because it has to do with the last refinements and the psychology of ventilation only.

These were the first two steps in the new era of ventilation, *first*—the discovery and admission of our ignorance and *second*—the recognition of these important factors.

The next step was to determine what bearing each of these factors had upon ventilation and to devise some means of expressing them in definite and comparable terms.

This work was undertaken by Dr. E. Vernon Hill, who assisted by O. W. Armspach, devised the Synthetic Air Chart which provides a method of determining the degree or effectiveness of ventilation in a room or building.

The synthetic air chart which was adopted as the Society's standard in 1920 is a convenient means by which the ventilating engineer can determine the percentage of perfection of ventilation in any occupied space. The percentage of perfection desirable depends upon the purpose for which the room is occupied. Dr. E. Vernon Hill suggests the percentages indicated in Table 89 as minimum requirements.

TABLE 89. DR. E. VERNON HILL'S RECOMMENDED PERCENTAGES OF VENTILATION PERFECTION FOR DIFFERENT CLASSES OF BUILDINGS WHEN TESTED ACCORDING TO THE SYNTHETIC AIR CHART

SCHOOLS	NEW BUILDINGS PER CENT	EXISTING BUILDINGS PER CENT
Class Rooms	95	90
Manual Training Rooms	90	85
Domestic Science Rooms	90	85
Assembly Rooms	90	85
Toilet Rooms	85	80
Corridors	85	80
Churches	85	80
HOSPITALS		
Wards	95	90
Operating Rooms	98	93
Other Rooms	90	85
THEATRES		
Seating Sections	90	85
Dressing Rooms, etc.	85	80
Dance, Lodge and Assembly Halls	88	83
OFFICE BUILDINGS		
Offices in office buildings or other buildings where persons are continuously employed	90	85
FACTORY BUILDINGS		

The percentage desirable for factory buildings will vary over a considerable range, depending upon the character of the work and of the process 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 a careful classification and considerable study.

FIVE CLASSIFICATIONS FOR EQUIPMENT

Engineering data is available for designing to meet these requirements. The following five classes of equipment suggested by Dr. Hill will give the percentage of perfection indicated when properly proportioned.

Class A—100 per cent equipment.—A mechanical supply and exhaust system consisting of the following:

1. Positive air supply having a maximum capacity of 30 c.f.m. per occupant.
2. Mechanical exhaust equipment with exhaust registers effectively located.
3. Perfect air distribution.
4. Accurate automatic temperature control.
5. Efficient humidifying devices.
6. Accurate automatic humidity controlling apparatus.
7. Efficient air washers, filters or other air cleaning devices, having an efficiency not less than 99 per cent.

It is understood that a 100 per cent efficient equipment is an impossibility owing to the fact that to secure a 100 per cent result would necessarily mean that air cleaning devices be 100 per cent efficient; that temperature and humidity control maintain temperature and humidity conditions absolutely on the comfort curve; that air distribution be perfect, etc. All these results cannot be obtained although a 99 per cent apparatus and an approximately 99 per cent test by the Synthetic Air Chart is possible.

Class B—95 per cent equipment.—Mechanical supply consisting of the following:

1. A positive air supply with a maximum capacity of 30 c.f.m. per occupant.
2. A well designed gravity exhaust system.
3. Efficient air distribution.
4. Accurate temperature control.
5. Adequate humidifying apparatus.
6. Adequate humidity control.

Air cleaning devices have been omitted in the 95 per cent equipment as this percentage can be obtained under ordinary conditions without air washers or filters. In an exceptionally clean locality, much higher percentages can be obtained.

Class C—90 per cent equipment.—A mechanical supply system consisting of the following:

1. An adequate air supply with 30 c.f.m. per occupant.
2. Gravity exhaust.
3. Efficient air distribution.
4. Automatic temperature control.
5. Adequate humidifying apparatus.
6. Humidity control in the main duct only or from a typical room.

Note.—Synthetic Air Chart—The final form of the Chart and the text will be revised and comfort based upon the equivalent temperature curve rather than on the wet bulb.

Class D—85 per cent equipment.—A mechanical system consisting of the following:

1. An accurate air supply with a maximum capacity of 30 c.f.m. per occupant.
2. Gravity exhaust or exhaust openings.
3. Good air distribution.
4. Automatic temperature control.

Class E—80 per cent equipment.

1. A positive air supply with gravity exhaust but without air cleaning devices, humidifying apparatus, temperature or humidity control.
2. Direct-indirect systems with either mechanical or gravity exhaust.
3. Open window or other so-called natural systems of ventilation.

A comprehensive discussion of the requirements of ventilation has been published[1] which suggests the following quantities of air to be supplied, under different conditions, to space used for various purposes as given in Table 90:

TABLE 90. AMOUNT OF NEW AIR TO BE SUPPLIED PER PERSON[1]

	Cubic Feet per Minute			Number of Air Changes per Hour
	Without Humidification or Recirculation	With Humidification but Without Recirculation	With Humidification and Recirculation	
SCHOOLS—				
Class Rooms	30	20	5 to 10	
Assembly Rooms	15 to 20	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
THEATERS—				
Seating Space	30 to 50	20 to 30	10 to 15	
HOSPITALS—				
Wards	30 to 40	20 to 30		
Kitchens				20 to 60
Dining Rooms				10 to 20
Toilets				10 to 20
HOTELS—				
Dining Rooms				10 to 15
Kitchens				20 to 60
Ball Rooms				5 to 10
Work Space				5 to 10
Assembly Rooms	20 to 30	15 to 20	10 to 15	

VENTILATION REQUIREMENTS

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

[1]Modern Trend in the Science of Ventilation, Perry West, TRANSACTIONS, AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS, Vol. 30, 1924.

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. from light etc., being given up to the building against 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 p. 29, Chapter 1).

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 (for ceilings 10 ft. or less in height) otherwise the ventilation will be drafty and uncomfortable. This difference may be increased 1 deg. for each 2 ft. of added ceiling height provided the rising air does not come into direct contact with another tier of occupants.

For 10 ft. and lower ceilings the quantity of air per person to dissipate this excess heat is $\frac{200}{60 \times .02 \times 5} = 33$ cu. ft. per person per min.

This amount may be reduced somewhat on the assumption that the component of heat from lights is usually introduced near the ceiling and may be allowed to heat the outgoing air to a greater difference.

In the practical work of engineers who design ventilating systems and of architects and owners who have to pass up on these systems, the one item involving standards which is the basis of all calculations and layouts, is the quantity of air to be handled by the system to be used, for producing 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 CO_2 and other objectionable substances down to the proper point, 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_2 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 breathed. The same air may be rebreathed for a limited time without apparent harmful affect but discomfort is evident. However air may be filtered, washed, cooled and recirculated with evident satisfaction. This was demonstrated under the stimulus of war time conditions and with the development of better equipment.

TABLE 91. AIR REQUIRED FOR VARIOUS PERCENTAGES OF VENTILATION PERFECTION

Percentage of Perfection	Cu. Ft. of Air per Minute Required per Person at Rest	Cu. Ft. of Air per Minute Required per Person at Hard Work
98%	15.0	30.0
96%	7.5	15.0
94%	5.0	10.0
92%	3.75	7.5
90%	3.0	6.0

The air handled may consist entirely of air taken in from the outside or it may consist partly of new air and partly of recirculated air. On the basis that the air brought in from the outside is for oxygen supply and dilution only. The following cubic feet per minute per person would be required for the ventilation percentages shown, if all other factors are 100 per cent perfect.

In theatres, assembly rooms, auditoriums and other places of public amusement and assemblage there are usually several other factors to consider, such as the removal of excess heat, excess moisture, dust raised by the movement of the occupants and odors.

EFFECT OF HIGH TEMPERATURE AND HUMIDITY

For 85 deg. outside air and 70 per cent relative humidity in the summer the percentage of perfection would drop to 57 per cent without any change in the air from outside conditions.

Assuming that the air supply is 30 cu. ft. per person and that the body heat and heat from equipment will raise this 5 deg. Also that the vapor added per person is 10 grains per min. or 0.33 grains per cu. ft. of air handled, the effective temperature difference will be raised about 20, so that the percentage of ventilation, would drop about 5 more, leaving 52 per cent ventilation. It will be seen, therefore, that it would be difficult to get better than 40 to 60 per cent ventilation in summer without some method of air cooling.

Air motion will assist but unless increased beyond the usual 10 to 20 ft. per minute ordinarily obtained from the movement of the air through the room it will not improve the percentage of ventilation more than 1 to 2 per cent. By the use of refrigerating and dehumidifying apparatus the effective temperature can be maintained at any desired percentage of perfection.

The use of a good air washer should reduce the temperature about 70 per cent of the difference between the wet and dry bulb temperature. This for the case cited would reduce the effective temperature difference about 2 deg. corresponding to an increase of 5 per cent in the final percentage of the ventilation.

It will be understood that the example cited is an extreme case of temperature and humidity and that the final percentage will be improved by the air washer in a greater proportion if the relative humidity of the outside air is lower.

For a condition of 80 deg. dry bulb and 50 of relative humidity, the percentage for the entering air would be 77 per cent, the percentage leaving the occupants would be 70 per cent and the air washer would improve this to 81 per cent.

Assuming that 90 per cent ventilation is desired for places of assemblage, that distribution will be 75 per cent, dust 96 per cent, bacteria 98 per cent and odors 85 per cent, there will be a deduction of 1 per cent for dust plus 1 per cent for bacteria plus 1.5 per cent for odor making a total of 3.5 per cent and leaving a deduction of 6.5 per cent for effective temperature plus effective air supply.

Assuming that the effective temperature can be controlled in winter to within 1 deg. above or below the comfort line there would be a deduction of 2½ per cent for this, leaving a deduction of 4 per cent for effective air supply. With 75 per cent distribution this would leave 3 per cent deduction for CO_2, corresponding to an air supply of 10 cu. ft. per min. per person.

It will be seen then that 10 cu. ft. of air taken in from the outside, per person per minute, is sufficient for winter conditions but inadequate for summer weather, where heat and humidity are the determining factors, unless refrigeration is used. Increasing the air supply from 10 to 50 cu. ft. per person per minute gives little improvement unless some form of artificial cooling is used.

SUMMER CONDITIONS

It would seem that about 75 per cent ventilation is possible under reasonably severe summer conditions with an air supply of 30 cu. ft. per person, using an air washer, and that beyond this point there is little to be gained by increasing the air supply. The figures given are based on upward ventilation and that the cooling effect of from 5 to 10 deg. with air washers and of perhaps twice this amount with refrigeration will produce uncomfortable drafts on the occupants at times.

For this reason and for the additional reasons of sanitation and control, the downward system of ventilation is perhaps more efficacious in large and intensely used places of assemblage.

On account of transporting all of the heat from lights downward and of forcing the body-heated air back over the occupants it is usually necessary to do much more cooling of the air than can be done with the air washer, without refrigeration. On the other hand the air is brought in high enough to permit of its being diffused and brought to the proper condition before coming into contact with the occupants. It can be seen, therefore, that the air supply per person per minute for assembly-rooms could be 10 cu. ft. in winter, 30 cu. ft. in summer with air washers and anywhere between these two figures for the entire year with refrigeration.

Also that nothing better than about 75 per cent ventilation can be obtained in hot sultry summer weather without artificial cooling but that with such cooling especially if the air supply is taken from overhead and exhausted from below, most any desired percentage of perfection can be maintained.

RECIRCULATION

The foregoing does not take into consideration the matter of recirculation, but it can readily be seen that there is little to be gained by recirculation unless an appreciable amount of CO_2 and attendant impurities which get into the air can be taken out during recirculation. The handling of the larger quantity of air may be of value either to produce air motion or for use as a better cooling medium with less temperature difference between incoming and outgoing air. Recirculation may also be used as a purely economic feature during the warming up of the building or during

periods when the space is only partly occupied and the mechanical arrangements are inadequate for properly varying the quantity of air handled to suit.

A good arrangement is to provide apparatus for handling 30 cu. ft. of air per person per minute with provisions for recirculating any amount up to as much as two-thirds of this.

The percentage of air recirculated may be varied to suit the seasonal changes so as to conserve heat in winter and refrigeration in summer. The schools where the requirements are not so severe and it is not necessary to provide for summer conditions as much as 90 per cent of the air can be successfully recirculated. The use of ozonation for eliminating odors and for otherwise refreshing the air is advisable wherever recirculation is regularly and intensively employed (see Chapter XXIII, p. 265).

Present methods of measuring and comparing qualities of ventilation not taking into account any of the functions of the relative humidity of the air except that bearing upon effective temperature. This means that air of any temperature and relative humidity, within proper physical range, *i.e.*, below 64 deg. wet bulb, may be made to meet the comfort line by either heating or cooling without addition or deduction of moisture.

Absolutely dry air may be heated or cooled to 78 deg. and be 100 per cent perfect as far as effective temperature is concerned and still be far from desirable in its effects on the membranes of nose, throat and lungs. Such dry air is also very conducive to the increase of dustiness in the atmosphere of a room from the standpoints of dryness and electrostatic agitation.

The air washer and humidifier correct these difficulties and there should be some definition of limits for the relative humidity in the measure of ventilation.

It is not unusual to find from 1 to 2 million particles of dust per cu. ft. in the outside air surrounding city buildings and unless this is eliminated it will give dust counts in rooms equivalent to a deduction of from 5 to 20 per cent in the perfection of ventilation.

A good air washer should eliminate 80 to 90 per cent of the dust entering the intake and perhaps reduce the dust penalty in the rooms to less than one-half of the figure given. It will be seen, therefore, that air washing and humidification may improve the quality of ventilation about 10 per cent in the effective temperature department, plus another 10 per cent in the dust department, plus other improvements in the quality of ventilation by maintaining proper humidity and removing other injurious substances and odors.

Where effective temperature is controlled, according to the usual method, from the dry bulb temperature in the room there may be a wide variation in this effective temperature due to the varying amounts of moisture in the air, unless humidifying apparatus with accurate humidity control is employed. Between the condition of absolute dry air at 70 per cent and absolutely saturated air at 70 deg. there is a difference of 10 deg. in effective temperature which means an average difference of 25 per cent in the quality of ventilation. This may be taken to mean about 10 per cent on each side of the neutral point for ordinary ventilating

conditions so that the air washer and humidity should improve the ordinary ventilating plant another 10 per cent on this count.

Good dry air filters will of course serve the same purpose for cleaning the air of suspended matter, and may improve the ventilation about 10 per cent.

SCHOOLS REQUIRE SPECIAL CONSIDERATIONS

In connection with the ventilation of schools the condition in the class-rooms for average winter weather is that the body heat given up to the room from the occupants is less than the heat loss from the building to the outside air so that the incoming air may be maintained at a higher temperature than that of the air surrounding the occupants. This means that the effective temperature may be controlled within 1 deg. above or below the comfort line.

Assuming that 95 per cent ventilation is required for class-rooms, that the distribution is 85 per cent and there is no deduction for dust, bacteria or odors, could have a deduction of 85 per cent of 2.5 per cent which is equivalent to about 2 per cent for CO_2. This would mean 15 cu. ft. of air per pupil per minute.

The usual requirements of state laws is 30 cu. ft. per pupil which would mean a deduction of 1 per cent for CO_2 leaving a 4 per cent deduction for effective temperature, dust, bacteria and odors.

Allowing a deduction of 2½ per cent for effective temperature there would be a possible deduction of 1½ per cent for these other items. It will depend therefore upon the quality that can be maintained for these other items as to the actual quantity of air required between 15 and 30 cu. ft. per minute per pupil.

Where intensive recirculation is employed the extent of the recirculation will depend on the quantity of CO_2, odors and other objectionable factors which can be removed from the recirculated air and also upon the ability to keep the relative humidity from rising to an undesirable point on account of the vapor given up to the air by occupants of the building.

The ventilation of school auditoriums where the occupancy of the rooms is of a relatively short duration of from 1 to 2 hours the initial air in the rooms may be relied upon to reduce the intensity of ventilation required so that from 15 to 20 cu. ft. of air per person per minute is usually sufficient. In the ventilation of hospitals the wards may be treated much the same as the class-rooms of a school with the exception that it is inadvisable to use recirculation on account of the danger of contagion.

School toilets should be separately ventilated with an air change of from 2 to 5 min. employing mechanical supply and exhaust with the exhaust in excess of the supply in order to prevent objectionable odors from diffusing into other parts of the building.

Kitchen and lunch rooms should be ventilated with about a 5 min. air change for lunch rooms and a 1 to 3 min. air change for kitchens with at least a part of the exhaust taken from the lunch rooms through the kitchen so as to keep all of the air travel towards the kitchen, thus preventing the kitchen odors from diffusing into the lunch rooms.

Exhaust from kitchen range hoods should be discharged by a separate exhaust fan through a fireproof metal duct extending above the roof of the building and provided with automatic fire damper and steam jet fire extinguisher for use in case of emergency as the accumulation of the grease vapors in this flue frequently cause a fire.

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 come in. Of all the things that go to make up success or failure these two are the most important. The one who lays out the plant should supervise, not only its installation, but testing and watch it until it is operating properly. Beyond this it must be kept in the hands of competent operators under the right supervision. Then and not until then, will good ventilation be obtained.

CHAPTER XVI

THE HILL SYNTHETIC AIR CHART

PERFECTION in ventilation depends upon the condition of the air in a room as affecting health and comfort rather than upon the quantity of outside air supplied. The known conditions of air which may affect human health and comfort are its temperature, humidity, air motion, dustiness, odor, bacterialogical content and carbon dioxide content.

The synthetic air chart, devised by Dr. E. Vernon Hill, and revised as a result of investigations by the Society's Research Laboratory is the accepted standard for grading the perfection of ventilation in any room by the conditions of the air itself.

According to the synthetic air chart Fig. 72 each of the conditions of the air which affect human health is rated in percentage of perfection in a separate column. The percentage of perfection as regards each factor is indicated by the height of the shaded area in that column. The percentage of penalization for imperfection as regards that factor is given by the difference between 100 per cent and the indicated per cent of perfection. The effect which the penalization for each factor will have on the composite penalization for all factors of ventilation of the room is given at the right hand side of the column. The sum of the penalizations for each of the factors as given in the right hand side of the various columns is taken as the total percentage of penalization representing the imperfection of ventilation for the room. The percentage of perfection of ventilation is 100 per cent minus this total and is indicated by the height of the shaded area in the last column to the right. The percentage of perfection for any factor is determined by crediting an ideal condition with 100 per cent and a condition impossible for life with zero per cent perfection. In other words, a condition, as pertains to any one of the five factors, that will produce death or permanent disability is rated at zero per cent perfect.

CONDITIONS OF MAXIMUM COMFORT

Temperature Humidity and Air Motion.—A person's feeling of warmth is determined, by the temperature, humidity and motion of the air. A single index of a person's feeling of warmth is given by a scale of effective temperature, which takes into consideration these three factors. This scale of effective temperature (abbreviated E. T.) has been determined by the Society's Research Laboratory and is discussed in Chapter XVII. For the average human being at rest an effective temperature of 64 deg. gives maximum comfort. Persons working at various rates are most comfortable at effective temperatures below 64 deg. The exact effective temperatures 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. E. T.
Light Work	62.5 deg. E. T.
Moderate Work	62 deg. E. T.
Hard Work	59.5 deg. E. T.

One hundred per cent perfection in ventilation, for people at rest exists when the effective temperature is 64 deg. Life is impossible for any

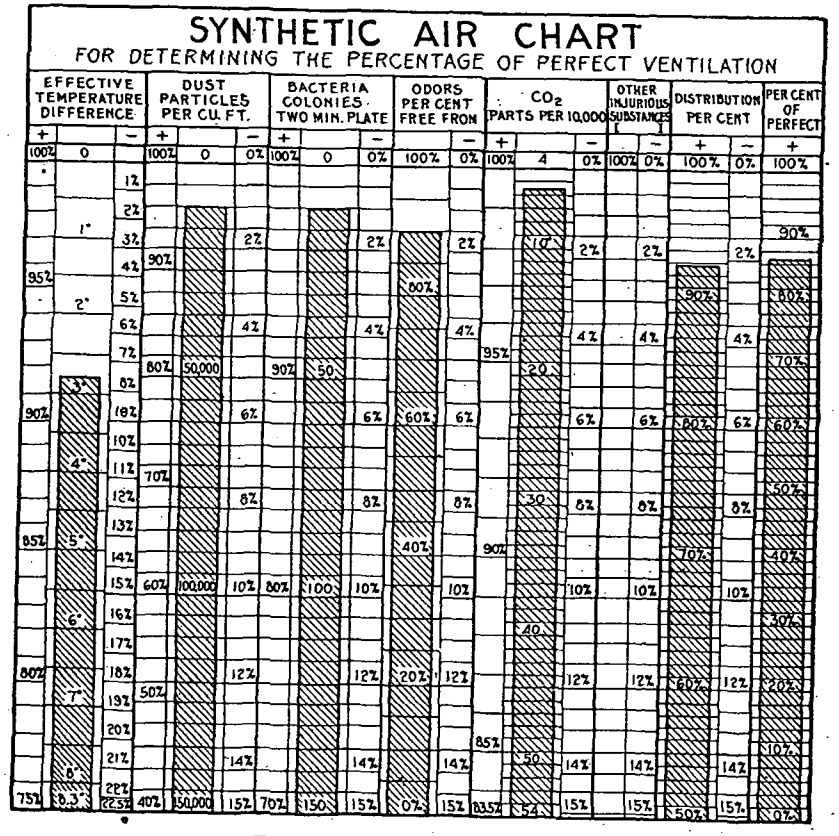


FIG. 72. SYNTHETIC AIR CHART

considerable length of time in an effective temperature of 97⅓ deg. and a condition having this effective temperature is therefore, rated zero per cent perfect, is penalized 100 per cent as regards this factor and 90 per cent for imperfection in ventilation. The penalization for variation in temperature from the ideal is therefore 3 per cent per deg. E. T. It will be noticed that this will give zero per cent perfection for 31 deg.—a condition at least nearly impossible for life for a person normally clothed and at rest.

Dust.—Dust is inimical to health and comfort. It is, however, more difficult to arrive at a basis of penalization since it is hard to say that any degree of dustiness is impossible for life. Dust free air is 100 per cent perfect and 250,000 particles per cu. ft. of air as determined by the Hill counter is considered zero per cent perfect, or is penalized 100 per cent as regards the dust factor and 25 per cent for imperfection of ventilation. The percentage of perfection is reduced by 1 per cent for each 2500 particles.

Odors.—In the case of odors it is even more difficult to arrive at a basis for penalization. The following arbitrary scale has been adopted:—

Free from odor	100 per cent perfect
Very faint odor	95 " " "
Faint odor	90 " " "
Noticeable odor	85 " " "
Distinct odor	80 " " "
Decided odor	75 " " "
Strong odor	70 " " "

Penalization for imperfection of ventilation is 0.15 of that for the odor factor.

Bacteria.—While all bacteria are not harmful and some may be desirable, the number of bacteria in the air generally indicates the surrounding sanitary condition and the chances for harmful bacteria may be assumed to be roughly proportional to the total number of bacteria in the air. According to the synthetic air chart, the percentage of perfection depends upon the number of bacteria in the air as determined by the number of growth appearing in a culture which has been exposed to the air for two minutes in a 4 in. petri dish and then incubated for 48 hrs. at 72 deg. If no colonies appear the condition is rated at 100 per cent and if 500 colonies appear it is rated at zero per cent perfect. The percentage of perfection is reduced by one for each 5 colonies for this factor while penalization for poor ventilation is one-half as great.

Carbon Dioxide.—The carbon dioxide content of the air may be taken as an indication of its purity. The percentage of perfection is 100 per cent if the carbon dioxide content is the same inside and outside and is reduced by 1 per cent for every three parts per 10,000 over that found in outside air. This gives 100 per cent penalization for 300 parts CO_2. Penalization for imperfect ventilation is 0.9 that for the CO_2 factor.

Distribution.—The distribution of the air throughout the room is an important factor in ventilation. Imperfection in this factor is determined by the variation in percentage of carbon dioxide in various parts of the room. In operating the synthetic air chart as many samples, as there are 200 sq. ft. of floor space in the room, or not less than four, of air from different parts of the room are analyzed. The percentage, which the average variation, of the various samples, is of the average CO_2 content, is the percentage penalization for poor distribution. Penalization for imperfect ventilation is 0.3 that for the distribution factor.

EXAMPLE IN THE USE OF THE CHART

Determine the percentage of perfection of ventilation in a room where the following conditions are observed. The room to be occupied by persons normally clothed and doing light work.

Dry Bulb Temperature	74 deg.
Wet Bulb Temperature	62 deg.
Air Velocity	50 ft. per min.
Dust Count by Hill Counter	10,000 particles per cu. ft.
Bacteria colonies developed in a 2 min. plate	10
Odors	Faint
CO_2 analysis inside Station No. 1	6 parts in 10,000
CO_2 analysis inside Station No. 2	6.3 parts in 10,000
CO_2 analysis inside Station No. 3	5.5 parts in 10,000
CO_2 analysis inside Station No. 4	5.0 parts in 10,000
CO_2 analysis outside	4.0 parts in 10,000
Other objectionable substances	None

The effective temperature for the observed wet and dry bulb temperature and air motion is determined from the Table 93 to 99 in Chapter XVII. From Table 94 (See Chapter XVII) for 50 ft. per min. air velocity the intersection of the line for 74 deg. dry bulb and the column for 62 deg. wet bulb gives 65.3 deg. as the E. T. of the condition. For 100 per cent perfection 62.5 deg. E. T. is required for persons doing light work whereas the existing condition is 65.3 deg. E. T. or 2.8 deg. too high, which gives according to the chart, 91.6 per cent perfection and 8.4 per cent penalization for this factor and a penalization of 7.6 per cent for imperfect ventilation. This is indicated in the chart, Fig. 72.

10,000 dust particles per cu. ft. of air gives according to the chart 96 per cent perfection and 4 per cent penalization for this factor and 1 per cent penalization for imperfect ventilation.

10 bacterial colonies on a 2 min. plate gives 98 per cent perfection for this factor and a penalization of 1 per cent for imperfect ventilation.

A faint odor or 90 per cent free from odors calls for a 10 per cent penalization for this factor and 1.5 per cent penalization for imperfection of ventilation.

The average carbon dioxide content of the 4 samples taken in the room is 5.7 or 1.7 parts more than the outside sample, which, according to the chart, is 99.5 per cent perfect for this factor and calls for 0.4 per cent penalization for imperfection of ventilation.

There are no other injurious substances indicated hence no penalization is given for such factors.

The variations of the carbon dioxide content of the four stations from their average are as follows:—

Station No. 1	6.3 − 5.7	= 0.6	parts per	10,000
" " 2	6.0 − 5.7	= 0.3	" "	10,000
" " 3	5.7 − 5.6	= 0.1	" "	10,000
" " 4	5.7 − 5.0	= 0.7	" "	10,000

$4\overline{)1.7}$

The average variation is $\frac{1.7}{4} = 0.42$, and the percentage of variation is $\frac{0.42}{5.7} \times 100 = 7.4$ per cent. Therefore the percentage distribution is $100 - 7.4 = 92.6$, and the percentage penalization for imperfect ventilation is 2.2.

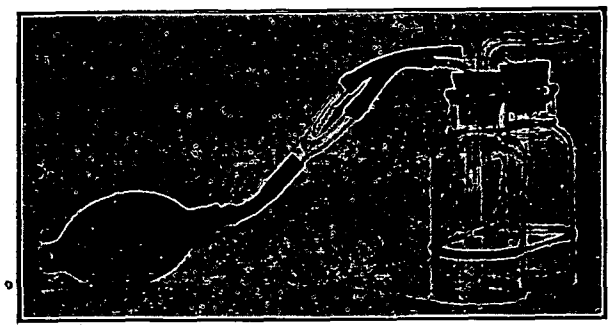


FIG. 73. AMMONIUM-CHLORIDE APPARATUS FOR DETERMINING VELOCITY AND DIRECTION OF AIR CURRENTS

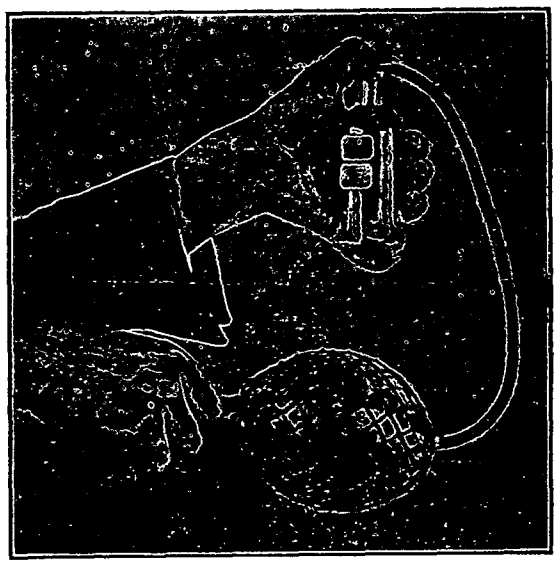


FIG. 74. TAKING AN AIR SAMPLE

The percentage of perfection for each factor is indicated in the chart, Fig. 72 and are summed up in Table 92. The sum of all the penalizations for imperfection in ventilation is 13.7 and the percentage of perfection of ventilation is 100 minus 13.7 or 86.3 which is shown in the last column of the chart.

TABLE 92. TYPICAL RESULTS OF ANALYSIS BY HILL SYNTHETIC AIR CHART

FACTOR	PERCENTAGE OF PERFECTION FOR FACTOR	PERCENTAGE OF PENALIZATION FOR FACTOR	PERCENTAGE OF PENALIZATION FOR IMPERFECT VENTILATION	PERCENTAGE OF PERFECTION FOR VENTILATION
Effective Temperature	9.6	8.4	7.6	.....
Dust	96.0	4.0	1.0	.....
Bacteria	98.0	2.0	1.0	.....
Odor	90.0	10.0	1.5	.....
Carbon Dioxide	99.5	0.5	0.4	.....
Distribution	92.6	7.4	2.2	.....
Total	.....	.....	13.7	86.3

The above observations are made as follows: The wet and dry bulb temperatures are determined with a sling psychrometer, the air velocity is determined by observing the speed of a smoke cloud with the aid of a stop watch. The smoke cloud may be caused by means of an ammonium cloud apparatus, Fig. 73 or by exploding a smoke bomb, or by other means.

The dust count is made by means of the Hill dust counter. In this instrument a given volume of air is made to impinge against a glass microscope cover slip coated with an adhesive. The particles are counted under a microscope of definite magnification and the number corrected per cu. ft. of air.

Carbon dioxide samples are taken in 120 cc. rubber stoppered bottles by exhausting air from the bottles with an atomizing bulb, Fig. 74. The bottle should be held at arms length while sampling so as not to be contaminated with the observer's breath and then tightly stopped until the sample can be analysed on a Peterson-Palmquist apparatus for carbon dioxide.

CHAPTER XVII

HOW TEMPERATURE, HUMIDITY AND AIR MOTION AFFECT HUMAN COMFORT

AN ordinary thermometer is only of relative value for indicating a person's feeling of comfort as the sense of warmth experienced by the human body is not due alone to the temperature registered by the dry bulb thermometer, neither does it depend solely upon the wet bulb temperature. Dry air at a relatively high temperature may feel cooler than air of considerably lower temperature with high moisture content according to the conclusions determined through a series of investigations conducted by the Society in conjunction with the U. S. Public Health Service and the U. S. Bureau of mines.

Human comfort or discomfort depend largely on body temperature and therefore on the relation between the rate of heat production and dissipation. By the process of metabolism heat is constantly generated within the body, while on the other hand, loss of heat is constantly occurring from the surface of the body by radiation, convection and evaporation. To maintain a constant body temperature the loss of heat 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 temperature reaches that of the body, the loss by radiation and convection ceases. Finally as the air temperature exceeds that of the body, heat passes from the air to the body.

If on the other hand, the relative humidity is increased the heat loss by evaporation decreases. If while the dry bulb temperature increases, the wet bulb temperature decreases sufficiently, the increase in loss of heat by evaporation may be made equal to the decrease in loss of heat by radiation and convection, resulting in no change in body temperature or comfort.

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

Prepared especially for THE GUIDE by F. C. Houghten, director of the AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS, Research Laboratory.

equal 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, both for still and moving air and the detailed data obtained is to be found in the Society's TRANSACTIONS, Vol. 27-31 inclusive, and in the JOURNALS for 1926.

The relation of temperature and humidity to comfort for persons normally clothed in still air is given in Fig. 75 while the effect of air motion upon comfort or effective temperatures for persons normally clothed are given in the Tables 93 to 99 which cover still and various moving air conditions.

HOW TO USE THE COMFORT CHART AND TABLES

In the Psychrometric Chart, 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 any temperature 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 dry bulb lines at low temperatures. The numerical value of the wet and effective temperature lines is given by the dry bulb temperature of their intersection with the saturation curve.

Dry bulb temperature is the true temperature of the air as determined by an ordinary thermometer. It does not, however, accurately indicate a person's feeling of warmth. If the humidity is high a person will feel warmer at the same dry bulb temperature than he will if the humidity is low.

Wet bulb temperature is not the temperature of the air but 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 is not thoroughly wet and hence does not react entirely in accordance with the wet bulb temperature. At high temperatures when the body is wet with perspiration, it reacts more nearly to wet bulb temperature while at low temperatures the body is comparatively dry and 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 and humidity. In other words with any given effective temperature a person will feel the same degree of warmth or coldness regardless of the dry bulb or wet bulb temperature.

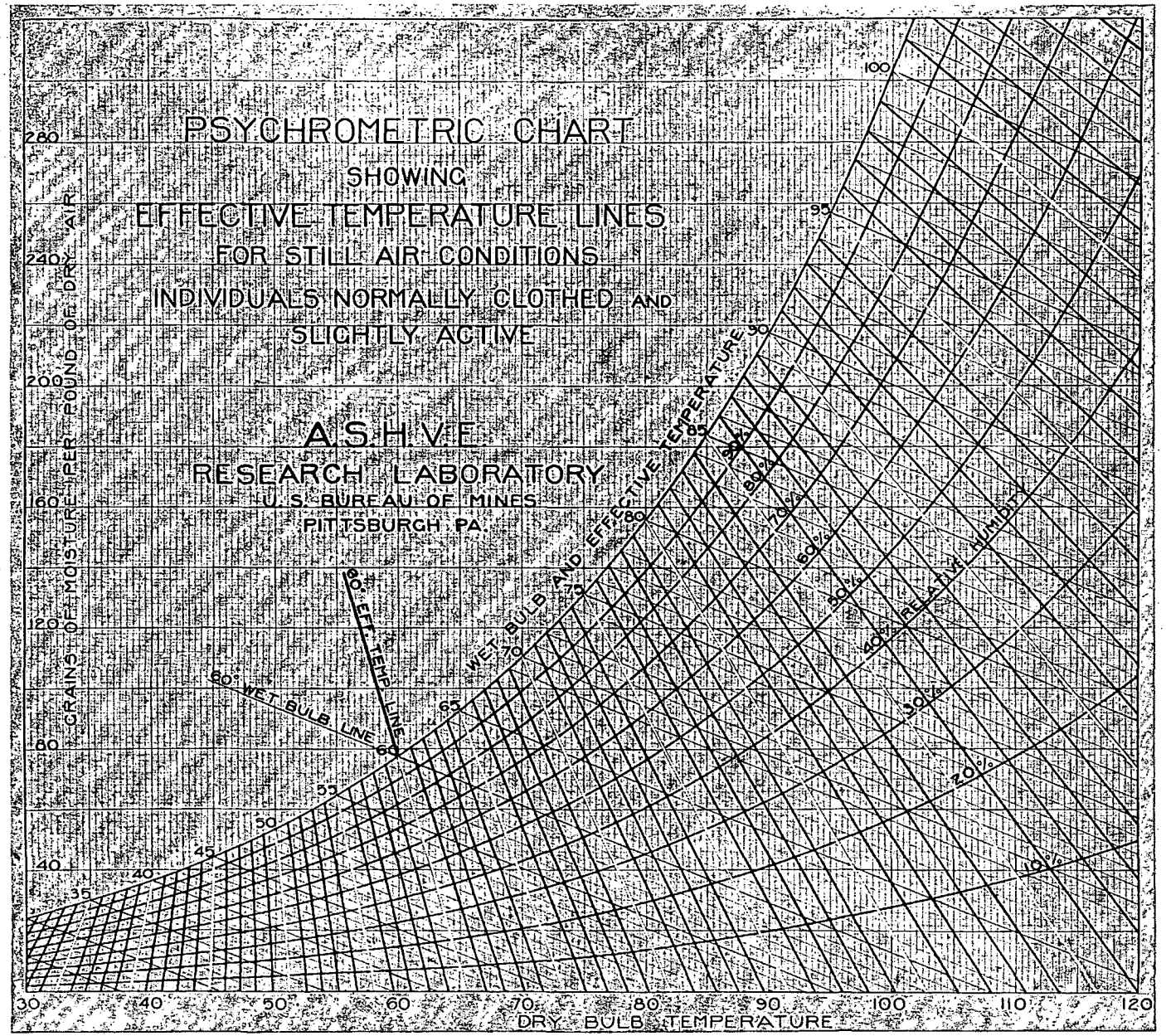


FIG. 75. STANDARD PSYCHROMETRIC CHART WITH EQUAL COMFORT LINES SUPERIMPOSED

THE COMFORT ZONE

That range of effective temperatures over which 50 per cent of people feel comfortable, namely 62 deg. effective temperature to 69 deg. effective temperature, is called the Comfort Zone.

That particular effective temperature at which a maximum number of people feel comfortable is 64 deg. effective temperature and is called the comfort line. While at rest in still air, 97 per cent of all people are comfortable at this temperature.

Tables 93 to 99 give the relation between dry and wet bulb temperatures, and effective temperature for still air, and various air velocities up to 700 ft. per min. for persons normally clothed.

The data given in the chart, Fig. 75, and Tables 93 to 99 are for persons normally clothed and differ somewhat from the data contained in previous editions of the Guide for person's stripped to the waist. The tables are divided into zones with correction factors in black face at the side which subtracted from the "normally clothed effective temperatures" will give the "stripped to the waist effective temperatures" with sufficient accuracy for all practical purposes.

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 will 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 95 deg. dry bulb and 40 per cent relative humidity having a wet bulb temperature of 75.2 deg. and effective temperature of 83.1 deg. This condition can be made equivalent to 80 deg. effective temperature or it can be made to feel 3.1 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 88.2 deg. (see Fig. 75) along the "100 grain moisture per pound of dry air" line when the effective temperature will be 80 deg.

(2) Without removal of sensible heat or lowering of the dry bulb the moisture content may be reduced from 100 to 54 grains per pound of dry air, when the effective temperature will be 80 deg.

(3) Upon inspection of Tables 98 and 99 it will be found that 95 deg. dry bulb and 75.2 deg. wet bulb will give 80.2 deg. effective temperature with 500 ft. air velocity and 79.6 deg. effective temperature with 700 ft. air velocity. Interpolation between these two velocities will give 567 as the velocity necessary to make this condition equivalent to 80 deg. effective temperature.

(4) Evaporation of water at room temperature without addition or removal of heat will cause the point on the chart Fig. 75, 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 86.2 deg. and the effective temperature will fall to 80 deg.

Table 93. Effective Temperature for Various Wet Bulb and Dry Bulb Temperatures for Still Air

Persons Normally Clothed and Slightly Active

Wet Bulb Temperature

Dry Bulb Temp.	25	30	35	40	45	49	52	54	56	58	60	62	64	66	68	70	72	74	77	80	85	90	95	100
Effective Temperature																								
30	32.0	30.0																						
35	37.0	36.2	35.0																					
40		41.0	40.6	40.0																				
45		45.1	45.1	45.0	45.0																			
50			49.1	49.3	49.7	50.0																		
54			52.1	52.4	52.9	53.3	53.8	54.0																
57				54.5	55.0	55.6	56.0	56.3	56.8															
60				56.4	57.0	57.7	58.2	58.6	59.0	59.5	60.0													
62				57.7	58.3	59.0	59.6	60.0	60.4	60.9	61.3	62.0												
64					59.6	60.3	60.9	61.2	61.8	62.2	62.8	63.3	64.0											
66					60.8	61.5	62.1	62.5	63.0	63.5	64.0	64.7	65.3	66.0										
68					62.0	62.7	63.3	63.8	64.3	64.8	65.3	65.9	66.5	67.2	68.0									
70					63.0	63.9	64.5	65.0	65.4	65.9	66.4	67.0	67.8	68.4	69.2	70.0								
72					64.2	65.0	65 6	66.0	66.5	67.0	67.6	68.2	68.9	69.6	70.3	71.1	72.0							
74						66.0	66.6	67.0	67.6	68.1	68.7	69.2	70.0	70.6	71.4	72.2	73.1	74.0						
76						67.0	67.7	68.1	68.7	69.1	69.8	70.3	71.0	71.7	72.4	73.2	74.1	75.0						
78						68.0	68.7	69.1	69.7	70.2	70.8	71.3	72.0	72.7	73.4	74.2	75.0	76.0	77.4					
80						69.0	69.7	70.1	70.6	71.1	71.7	72.3	73.0	73.7	74.4	75.2	76.0	76.9	78.3	80.0				
83							71.0	71.4	72.0	72.5	73.1	73.7	74.3	75.0	75.8	76.5	77.2	78.2	79.7	81.2				
86							72.3	72.8	73.3	73.9	74.4	75.0	75.7	76.2	77.0	77.8	78.6	79.4	80.8	82.4	85.4			
90								74.5	75.0	75.5	76.0	76.6	77.2	77.9	78.6	79.3	80.1	80.9	82.3	83.8	86.6	90.0		
95									76.8	77.3	77.9	78.5	79.1	79.8	80.3	81.1	81.8	82.6	84.0	85.4	88.0	91.2	95.0	
100										79.1	79.6	80.2	80.8	81.3	82.0	82.7	83.4	84.2	85.4	86.7	89.3	92.3	95.8	100.0
105											81.1	81.7	82.2	82.8	83.4	84.1	84.8	85.5	86.7	88.0	90.4	93.2	96.7	100.6
110												83.0	83.6	84.2	84.8	85.4	86.0	86.7	87.7	89.0	91.3	94.0	97.3	101.2
120														86.4	86.9	87.5	88.2	88.8	89.8	90.9	93.0	95.6	98.5	102.2
												3.0		2.0					1		0			

Note.—To obtain the effective temperatures for a person stripped to the waist, for any wet and dry bulb reading: subtract from the normally clothed effective temperature, the factor for the particular belt or zone found at the edge of the Table.

Table 94. Effective Temperature for Various Wet Bulb and Dry Bulb Temperatures with an Air Velocity of 50 Ft. per Minute

Persons Normally Clothed and Slightly Active

Wet Bulb Temperature

Dry Bulb Temp.	25	30	35	40	45	49	52	54	56	58	60	62	64	66	68	70	72	74	77	80	85	90	95	100
Effective Temperature																								
30																								
35	34.1	33.2	31.9			5																		
40	7	38.6	38.0	37.3																				
45		43.2	43.0	42.9	42.6			4																
50			47.6	47.7	47.9	48.0																		
54			50.9	51.0	51.3	51.7	51.9	52.1				3												
57		6		53.3	53.7	54.1	54.5	54.8	55.1															
60				55.2	55.9	56.4	57.0	57.2	57.7	58.0	58.6													
62				56.7	57.3	57.9	58.4	58.8	59.2	59.7	60.1	60.7												
64					58.7	59.2	59.8	60.2	60.6	61.1	61.6	62.1	62.7			2								
66					59.9	60.6	61.1	61.6	62.0	62.4	63.0	63.5	64.1	64.8										
68					61.1	61.9	62.4	62.9	63.3	63.8	64.2	64.9	65.5	66.1	66.8									
70					62.3	63.1	63.6	64.0	64.5	65.0	65.6	66.2	66.7	67.4	68.1	69.0								
72					63.6	64.2	64.9	65.3	65.8	66.2	66.8	67.3	68.0	68.7	69.3	70.2	71.0							
74						65.4	66.1	66.5	67.0	67.4	68.0	68.5	69.1	69.9	70 5	71.3	72.1	73.1		1				
76						66.6	67.1	67.5	68.0	68.5	69.0	69.7	70.3	70.9	71.6	72.4	73.2	74.1						
78						67.6	68.2	68.6	69.0	69.6	70.1	70.7	71.3	72.0	72.8	73.4	74.2	75.2	76.7					
80						68.6	69.1	69.6	70.1	70.6	71.1	71.8	72.3	73.0	73.7	74.4	75.3	76.2	77.6	79.2				
83							70.6	71.0	71.5	72.0	72.6	73.2	73.8	74.4	75.1	75.9	76.7	77.6	79.0	80.6				
86							72.0	72.5	73.0	73.4	74.0	74.5	75.1	75.8	76.4	77.2	78.0	78.8	80 2	81.8	84.7			0
90								74.2	74.6	75.1	75.7	76.2	76.8	77.4	78.0	78.8	79.6	80.4	81.8	83.2	86.2	89.6		
95									76.6	77.1	77.6	78.2	78.7	79.3	80.0	80.7	81.4	82.2	83.4	84.9	87.7	90.9	94.7	
100										78.9	79.3	79.8	80.3	81.0	81.6	82.3	83.0	83.8	85.0	86.3	88.9	92.0	95.6	100.0
105											80.9	81.4	81.9	82.6	83.2	83.8	84.5	85.2	86.3	87.6	90.1	93.0	96.4	100.6
110												82.9	83.4	83.9	84.5	85.1	85.8	86.4	87.5	88.8	91.1	93.9	97.2	101.2
120														86.2	86.8	87.3	87.9	88.6	89.7	90.8	92.9	95.3	98.4	102 3

Note.—To obtain the effective temperatures for any wet and dry bulb reading for a person stripped to the waist: subtract from the normally clothed effective temperature as found in the chart, the factor at the edge of the Table for the particular belt or zone.

TABLE 95. EFFECTIVE TEMPERATURE FOR VARIOUS WET BULB AND DRY BULB TEMPERATURES WITH AN AIR VELOCITY OF 100 FT. PER MINUTE

Persons Normally Clothed and Slightly Active

Wet Bulb Temperature

Dry Bulb Temp.	25	30	35	40	45	49	52	54	56	58	60	62	64	66	68	70	72	74	77	80	85	90	95	100
Effective Temperature																								
30			9.0			8.0																		
35	31.5	30.2																						
40		36.3	35.5	34.5				7.0																
45		41.3	41.0	40.6	40.0																			
50			46.0	45.9	45.9	45.8				6.0														
54			49.4	49.5	49.7	49.9	50.0	50.2				5.0												
57				52.0	52.3	52.7	53 0	53 1	53.4															
60				54.3	54.8	55.2	55.6	55.8	56.1	56.5	56.9													
62				55.8	56.2	56.7	57.2	57.5	57.9	58.2	58.6	59.0			4.0									
64					57.7	58.2	58.7	59.0	59.4	59.9	60.2	60.8	61.3											
66					59 1	59.7	60.1	60.5	60.9	61.3	61.9	62.3	63 0	63.6										
68					60.4	61.0	61.6	62.0	62.3	62.9	63.3	63.8	64.3	65.0	65.7		3.0							
70					61.8	62.3	62.9	63.3	63.7	64.1	64.7	65.2	65.8	66.4	67.0	68.0								
72					63.0	63.6	64.1	64.5	65.0	65.4	66.0	66.5	67.0	67.7	68.4	69.2	70.0							
74						64.7	65.3	65.8	66.2	66.7	67.1	67.8	68.3	69.0	69.8	70.5	71.2	72.2	2.0					
76						66.0	66.5	67.0	67.3	67.8	68.3	69.0	69.6	70.2	70.9	71.6	72.4	73.3						
78						67.0	67.6	68.0	68.4	69.0	69.5	70.0	70.6	71.3	72.0	72.8	73.5	74.4	75.9		1.0			
80						68.0	68.7	69.1	69.5	70.0	70.5	71.1	71.8	72.4	73.1	73.8	74.7	75.4	77.0	78.6				
83							70.1	70.6	71.0	71 5	72.1	72.7	73.2	73.9	74.6	75.3	76.1	76.9	78.3	80.0			0.0	
86							71.6	72 0	72.5	73.0	73 5	74.0	74.7	75.3	76.0	76.7	77.4	78.2	79.7	81.2	84.1			
90								73.8	74.2	74.8	75.3	75 8	76.3	77.0	77.7	78.3	79.1	80.0	81.2	82.8	85.6	89.0		
95									76.2	76.7	77.2	77.8	78.3	78.9	79.6	80.3	81.0	81.8	83.0	84.5	87.2	90.4	94.5	
100										78.5	79.0	79.5	80.1	80.7	81.3	82.0	82.6	83.4	84.7	86.0	88.5	91.6	95.4	100.0
105											80.7	81.2	81.7	82.2	82.8	83,5	84.2	84.9	86.0	87.3	89.8	92.7	96.2	100.6
110												82.6	83.1	83.7	84.2	84.8	85.5	86.2	87.3	88.6	90.8	93.7	97.0	101.1
120														86.2	86.7	87.3	87.8	88.4	89.4	90.6	92.7	95.2	98.3	102.1

Note.—To obtain the effective temperatures for a person stripped to the waist, for any wet and dry bulb reading: subtract from the normally clothed effective temperature, the factor for the particular belt or zone found at the edge of the Table.

TABLE 96. EFFECTIVE TEMPERATURE FOR VARIOUS WET BULB AND DRY BULB TEMPERATURES WITH AN AIR VELOCITY OF 200 FT. PER MINUTE

Persons Normally Clothed and Slightly Active

Wet Bulb Temperature

Dry Bulb Temp.	25	30	35	40	45	49	52	54	56	58	60	62	64	66	68	70	72	74	77	80	85	90	95	100
Effective Temperature																								
30																								
35																								
40		31.9	30.8			13.0																		
45		38.0	37.2	36.4	35.6																			
50			42.7	42.5	42.0	41.8		10.5																
54			46.8	46.8	46.8	46.8	46.7	46.7		9.0														
57				49.5	49.8	49.9	50.0	50.1	50.2			8.0												
60				52.0	52.4	52.8	53.0	53.2	53.4	53.7	54.0			7.0										
62				53.7	54.0	54.5	54.8	55.0	55.3	55.6	56.0	56.5												
64					55.7	56.1	56.5	56.9	57.1	57.5	57.9	58.3	58.9			6.0								
66					57.2	57.8	58.2	58.6	59.0	59.2	59.6	60.0	60.5	61.0			5.0							
68					58.8	59.3	59.8	60.0	60.4	60.9	61.3	61.8	62.2	62.9	63.5									
70					60.1	60.8	61.2	61.6	62.0	62.4	62.9	63.3	63.9	64.5	65.1	65.9								
72					61.5	62.2	62.6	63.0	63.4	63.9	64.3	64.9	65.4	66.0	66.7	67.3	68.0		4.0					
74						63.5	64.0	64.4	64.9	65.3	65.8	66.3	66.9	67.4	68.0	68.8	69.5	70.3						
76						64.9	65.4	65.8	66.2	66.7	67.1	67.7	68.1	68.8	69.3	70.0	70.9	71.7		3.0				
78						66.0	66.7	67.0	67.5	67.9	68.3	68.9	69.4	70.0	70.6	71.3	72.0	72.9	74.3					
80						67.3	67.8	68.2	68.6	69.1	69.5	70.0	70.6	71.2	71.8	72.5	73.2	74.1	75.5	77.0	2.0			
83							69.4	69.8	70.2	70.7	71.2	71.7	72.2	72.9	73.5	74.2	75.0	75.8	77.1	78.7				
86							71.0	71.4	71.8	72.2	72.7	73.2	73.8	74.4	75.1	75.8	76.5	77.3	78.7	80.1	83.1		0.0	
90								73.3	73.8	74.2	74.7	75.2	75.8	76.3	76.9	77.7	78.3	79.1	80.4	81.9	84.7	88.1		
95									75.9	76.3	76.8	77.3	77.9	78.5	79.0	79.7	80.3	81.1	82.4	83.8	86.4	89.7	94.0	
100										78.3	78.8	79.2	79.8	80.3	80.9	81.5	82.2	83.0	84.2	85 4	88.0	91.0	94 9	100.0
105											80.4	80.9	81.4	82.0	82.5	83.2	83.8	84.6	85.7	86.9	89.3	92.2	95.8	100.7
110												82.5	83.0	83.5	84.1	84.7	85.2	85.9	87.0	88.3	90.4	93.2	96.7	101.3
120										1.0				86.1	86.6	87.2	87.8	88.3	89.3	90.3	92.3	94.9	98.0	102.4

Note.—To obtain the effective temperatures for a person stripped to the waist, for any wet and dry bulb reading: subtract from the normally clothed effective temperature, the factor for the particular belt or zone found at the edge of the Table.

TABLE 97. EFFECTIVE TEMPERATURE FOR VARIOUS WET BULB AND DRY BULB TEMPERATURES WITH AN AIR VELOCITY OF 300 FT. PER MINUTE

Persons Normally Clothed and Slightly Active

Wet Bulb Temperature

DRY BULB TEMP.	25	30	35	40	45	49	52	54	56	58	60	62	64	66	68	70	72	74	77	80	85	90	95	100
Effective Temperature																								
30																								
35																								
40																								
45		35.0	34.1	33.1	31.9		**13.0**																	
50			40.0	39.8	39.2	38.7																		
54				44.0	44.0	43.9	43.8	43.7			**11.0**													
57				47.1	47.2	47.2	47.3	47.3	47.4				**9.0**											
60				50.0	50.2	50.4	50.7	50.9	51.0	51.1	51.3			**8.0**										
62				51.9	52.1	52.4	52.7	52.9	53.0	53.2	53.6	53.9												
64					54.0	54.3	54.6	54.9	55.0	55.3	55.7	55.9	56.3											
66					55.7	56.1	56.4	56.7	57.0	57.2	57.6	57.9	58.3	58.9		**7.0**	**6.0**							
68					57.2	57.8	58.1	58.4	58.8	59.1	59.4	59.8	60.2	60.7	61.2									
70					58.9	59.3	59.8	60.1	60.4	60.8	61.2	61.6	62.0	62.6	63.1	63.8		**5.0**						
72					60.4	61.0	61.3	61.7	62.0	62.3	62.8	63.2	63.8	64.3	65.0	65.6	66.3							
74						62.3	62.8	63.2	63.6	64.0	64.4	64.9	65.3	66.0	66.5	67.1	67.9	68.7	**4.0**	**3.0**				
76						63.8	64.2	64.7	65.0	65.4	65.9	66.3	66.9	67.4	68.0	68.7	69.3	70.1						
78						65.2	65.6	66.0	66.3	66.8	67.2	67.8	68.2	68.8	69.4	70.1	70.8	71.6	73.0					
80						66.3	66.8	67.2	67.7	68.1	68.6	69.0	69.6	70.1	70.8	71.3	72.1	73.0	74.2	75.7	**2.0**			
83							68.7	69.1	69.5	69.9	70.3	70.9	71.4	72.0	72.7	73.3	74.0	74.8	76.0	77.4		**1.0**		
86							70.4	70.8	71.2	71.6	72.1	72.6	73.1	73.7	74.3	75.0	75.6	76.3	77.7	79.0	82.0			
90								72.9	73.3	73.8	74.2	74.8	75.2	75.7	76.3	77.0	77.7	78.3	79.6	81.0	83.8	87.2		**0.0**
95									75.6	76.0	76.4	76.9	77.4	78.0	78.6	79.2	79.9	80.6	81.8	83.1	85.7	89.0	93.3	
100										78.0	78.4	79.0	79.5	80.0	80.6	81.2	81.8	82.4	83.6	84.9	87.3	90.5	94.6	100.0
105											80.3	80.7	81.2	81.7	82.3	82.8	83.4	84.2	85.2	86.4	88.8	91.8	95.6	100.7
110												82.3	82.8	83.3	83.8	84.3	85.0	85.6	86.6	87.8	90.0	92.9	96.6	101.3
120														85.9	86.4	86.9	87.4	88.0	89.0	90.1	92.2	94.7	98.0	102.3

Note.—To obtain the effective temperatures for a person stripped to the waist, for any wet and dry bulb reading: subtract from the normally clothed effective temperature, the factor for the particular belt or zone found at the edge of the Table.

TABLE 98. EFFECTIVE TEMPERATURE FOR VARIOUS WET BULB AND DRY BULB TEMPERATURES WITH AN AIR VELOCITY OF 500 FT. PER MINUTE

Persons Normally Clothed and Slightly Active

Wet Bulb Temperature

DRY BULB TEMP.	25	30	35	40	45	49	52	54	56	58	60	62	64	66	68	70	72	74	77	80	85	90	95	100
Effective Temperature																								
30																								
35																								
40																								
45	**13.0**	31.5	30.3																					
50			36.9	36.1	35.2	34.3																		
54		**10.5**		41.0	40.7	40.2	39.8	39.6																
57				44.4	44.3	44.1	44.0	44.0	43.8															
60				47.6	47.6	47.7	47.6	47.6	47.7	47.8	47.8													
62			**9.0**	49.6	49.8	49.8	50.0	50.0	50.0	50.1	50.3	50.5												
64					51.7	51.9	52.0	52.1	52.2	52.5	52.6	52.9	53.1											
66			**8.0**		53.5	53.8	54.0	54.2	54.4	54.7	55.0	55.2	55.5	55.9										
68					55.2	55.8	56.0	56.2	56.5	56.8	57.0	57.3	57.7	58.0	58.3									
70					57.1	57.6	57.9	58.1	58.4	58.6	58.9	59.2	59.7	60.0	60.5	61.0								
72				**7.0**	58.8	59.2	59.6	59.9	60.1	60.4	60.8	61.1	61.5	62.0	62.3	63.0	63.5							
74						60.8	61.2	61.5	61.9	62.2	62.5	62.9	63.3	63.8	64.2	64.8	65.3	66.0						
76						62.4	62.9	63.1	63.5	63.8	64.2	64.6	65.0	65.4	66.0	66.5	67.1	67.8						
78					**6.0**	64.0	64.4	64.8	65.0	65.3	65.8	66.2	66.6	67.0	67.6	68.1	68.8	69.4	70.5					
80						65.4	65.9	66.2	66.5	66.8	67.2	67.7	68.0	68.6	69.1	69.8	70.3	71.0	72.1	73.4				
83						**5.0**	67.7	68.2	68.6	69.0	69.3	69.8	70.2	70.7	71.2	71.9	72.4	73.1	74.2	75.4				
86							69.8	70.2	70.4	70.8	71.2	71.7	72.1	72.6	73.1	73.7	74.3	75.0	76.2	77.4	80.1			
90						**4.0**		72.4	72.8	73.2	73.6	74.0	74.4	74.9	75.4	76.0	76.7	77.3	78.4	79.8	82.2	85.6		
95							**3.0**		75.3	75.7	76.1	76.5	77.0	77.4	78.0	78.6	79.2	79.8	80.9	82.0	84.6	87.8	92.3	
100								**2.0**		77.9	78.3	78.8	79.2	79.6	80.1	80.7	81.2	81.8	82.9	84.1	86.5	89.5	93.8	100.0
105									80.2	80.6	81.0	81.4	82.0	82.5	83.0	83.7	84.7	85.8	88.2	91.0	95.0	100.1		
110										**1.0**		82.2	82.7	83.1	83.6	84.1	84.7	85.3	86.2	87.3	89.5	92.3	96.0	101.3
120												**0.0**		85.8	86.3	86.8	87.3	87.9	88.8	89.8	91.8	94.3	97.6	102.5

Note.—To obtain the effective temperatures for a person stripped to the waist, for any wet and dry bulb reading: subtract from the normally clothed effective temperature, thefactorfor the particular belt or zone found at the edge of the Table.

TABLE 99. EFFECTIVE TEMPERATURE FOR VARIOUS WET BULB AND DRY BULB TEMPERATURES WITH AN AIR VELOCITY OF 700 FT. PER MINUTE

Persons Normally Clothed and Slightly Active

Wet Bulb Temperature

Effective Temperature

Dry Bulb Temp.	25	30	35	40	45	49	52	54	56	58	60	62	64	66	68	70	72	74	77	80	85	90	95	100
30																								
35																								
40																								
45																								
50			35.0	34.0	32.8	31.1	37.2	36.8	41.4		17.0													
54				39.4	38.8	38.0	42.0	41.8	45.7	45.6	45.6	48.2												
57				43.0	42.7	42.2	46.0	45.9	48.2	48.2	48.2	51.0	51.1											
60				46.3	46.1	46.0	48.2	48.2	50.7	50.8	50.9	53.4	53.6	53.9	14.0									
62				48.3	48.3	48.3	50.6	50.7	53.0	53.0	53.2	55.7	56.0	56.2	56.5	59.1	12.0							
64					50.3	50.5	52.8	52.9	55.0	55.2	55.4	57.8	58.0	58.3	58.8	61.2	61.8	64.2						
66					52.3	52.6	54.8	54.9	57.0	57.2	57.4	59.8	60.0	60.4	60.8	63.2	63.7	66.1	9.5					
68					54.3	54.5	56.6	56.8	58.9	59.1	59.4	61.6	62.0	62.4	62.8	65.1	65.6	68.0	68.9					
70					56.0	56.3	58.3	58.6	60.4	60.7	61.2	63.1	63.8	64.1	64.6	66.8	67.3	69.6	70.6	71.8				
72					57.8	58.1	59.9	60.1	60.4	60.7	62.4	64.7	65.0	65.8	66.3	68.0	68.4	69.0	69.6	71.9	73.0	74.1		
74						59.9	61.4	62.1	61.9	62.4	63.8	64.3	65.4	65.8	66.2	67.4	68.0	68.4	69.0	69.6	71.9	74.0	75.0	76.2
76						61.4	63.1	63.5	63.8	64.0	64.3	64.7	65.0	65.4	65.8	66.2	66.6	67.0	67.4	68.0	68.4	69.0	69.6	71.8
78						63.1	64.6	65.0	65.2	65.5	65.8	66.2	66.6	67.0	67.4	67.8	68.0	68.4	69.0	69.6	70.6	71.3	71.9	73.4
80						64.6	65.0	65.2	65.6	65.8	66.2	66.6	67.0	67.4	67.8	68.0	68.4	68.8	69.4	69.8	70.8	71.3	71.9	72.8
83							67.1	67.4	67.8	68.0	68.5	68.9	69.3	69.8	70.2	70.8	71.3	71.9	72.5	73.0	74.1	74.6	75.0	75.5
86							69.2	69.5	69.8	70.2	70.6	71.0	71.3	71.8	72.3	72.8	73.4	73.9	74.5	75.0	76.2	76.7	77.1	77.6
90								71.9	72.2	72.6	73.0	73.4	73.9	74.3	74.8	75.3	75.9	76.5	77.1	77.5	78.7	79.2	79.6	80.1
95									73.0	73.3	75.7	76.0	76.5	76.9	77.4	77.9	78.5	79.2	79.8	80.2	81.3	81.8	82.2	82.7
100										77.6	77.9	78.3	78.8	79.3	79.8	80.2	80.8	81.4	82.0	82.4	83.6	84.0	84.4	84.9
105											80.0	80.3	80.8	81.2	81.8	82.2	82.8	83.3	84.0	84.3	85.3	85.7	86.1	86.6
110												82.1	82.5	82.9	83.3	83.8	84.3	84.9	85.6	85.8	87.0	87.4	87.8	88.3
120														85.6	86.1	86.6	87.0	87.6	88.5	89.2	91.5	91.9	92.3	92.8

	1.5	3.5	5.5	7.5	9.5	12.0	14.0	17.0
0.0	84.7	87.1	89.0	91.6	93.3	94.8	95.8	97.6
1.5	87.1	89.0	91.6	93.3	94.8	95.8	97.6	100.0
3.5	89.0	91.6	93.3	94.8	95.8	97.6	100.0	102.4
5.5	91.6	93.3	94.8	95.8	97.6	100.0	102.4	104.9
7.5	93.3	94.8	95.8	97.6	100.0	102.4	104.9	107.3
9.5	94.8	95.8	97.6	100.0	102.4	104.9	107.3	109.8
12.0	95.8	97.6	100.0	102.4	104.9	107.3	109.8	112.2
14.0	97.6	100.0	102.4	104.9	107.3	109.8	112.2	114.7
17.0	100.0	102.4	104.9	107.3	109.8	112.2	114.7	117.1

Note.—To obtain the effective temperatures for a person stripped to the waist, for any wet and dry bulb reading: subtract from the normally clothed effective temperature, the factor for the particular belt or zone found at the edge of the Table.

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 removal of heat or water vapor or both, are most effective. However excepting under unusually favorable circumstances direct cooling or dehumidifying is an expensive process and can only be resorted to where the results will justify the cost. Effective cooling by air motion or evaporation of water is relatively much less expensive. Unfortunately however these methods of cooling are limited to certain conditions of temperature and humidity. 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 experienced 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 summer condition of 96 deg. 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 temperature 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.

Example 1.—Given dry bulb and wet bulb temperatures 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 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 65 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 5 deg. effective temperature warmer than the comfort line.

Example 3.—Given the dry and wet bulb temperatures in a room of 76 and 54 deg. respectively, what air velocity will be necessary to make this condition ideally comfortable, that is, 65 deg. effective temperature?

Answer.—From Table 93 for still air it will be seen that this condition has an effective temperature of 68.1 deg. in still air. Looking through the various Tables 94 to 99 for moving air it will be found that with a 300 ft. velocity this condition will have an effective temperature of 64.7 deg., and with a velocity of 200 ft. (Table 96) it will have an effective temperature of 65.8 deg. Interpolating between these two velocities the desired velocity is found to be 273 ft. per min.

Example 4.—Given a condition having dry and wet bulb temperatures 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 Table 93 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 Table 97 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.

In practice these theoretical values will not be fully achieved. Therefore an allowance should be made for an increase in temperature and a decrease in humidity of the diffusing air before it strikes the occupants. The clothing worn and the kind of work done will also have a retarding effect. The experimental evidence now available, of the laws governing the cooling of the human body is of great value in predicting just what may be expected of a definite air velocity at a given temperature and moisture content when directed upon the body of lightly clothed individuals. Complete reports with other detailed examples of the use of Laboratory Human Comfort Data are to be found in the A. S. H. V. E. TRANSACTIONS, Vol. 27-31 for 1921 to 1925 inclusive.

There are many applications for these data. In warm weather it is especially desirable to have greater comfort in school rooms, theaters, 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 is however frequently resorted to in theaters and other public buildings and this practice may be expected to increase. While increased comfort due to cooling is expensive and while it may generally be considered a luxury there are few other luxuries which offer as much real comfort for the money expended. The fact that provision for cooling in hot weather is not found in more homes, clubs and places of assembly is largely due to the fact that possible comfort to be attained, from this source has not been clearly demonstrated to the building public by the air conditioning engineer.

CHAPTER XVIII

SYSTEMS OF VENTILATION

VENTILATION whether natural or mechanical, means the displacement of vitiated air from any enclosure and its replacement with fresh air. The systems may be classified as follows:—

Method of Supply	Method of Exhaust
Window	Gravity
Gravity	Fan
Fan	Gravity
Fan	Fan (with or without recirculation)

The movement of air in natural ventilation systems is produced by the difference in density between the column of air in the ducts and the outside air. The greater the difference in temperature between the two columns of air the more rapid the air movement.

In mechanical systems the circulation of air is maintained positively and uniformly regardless of outside air conditions and when properly designed and operated they will furnish any required temperature or humidity under automatic control.

Five methods of fan application in heating and ventilating are common as follows:

1. Fan system supplies both heating and ventilation.
2. Fan provides air for ventilation, direct radiation supplies heat.
3. Fan provides air for ventilation and portion of heating, remainder supplied by direct radiation.
4. Fan system does entire heating (no ventilation supplied).
5. Fan system provides ventilation exclusively.

Typical installations of the first 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 system is usually provided in hotel, 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. System four is especially adapted to industrial plants and shops to convey heat to the points desired and create an effective air motion, and uniform temperature with minimum heat loss. When the fan is required to do both heating and ventilating it is necessary to keep the fans in operation and great success has been reported in school work with systems of this kind

particularly because of its flexibility, absolute temperature and humidity control and economy of operation.[1]

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. For heating purposes only, the fan system may or may not be used, depending on circumstances and the requirements to be met. The fan system may be used to supply both heat and fresh air for ventilation, or it may be used in conjunction with some form of direct radiation which is to care for the heat losses. 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 may blow the air through the heaters, 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 the advantage gained by connecting directly to the piping system. In this case the temperature of the air delivered will be the same to all parts of the building. The blow-through apparatus is used in public buildings, or wherever different temperatures and independent temperature regulation are required for different rooms of the building. The use of the 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 from the heater, and from the by-pass, join to form one duct leading to the room. In the case of public buildings, the 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. They are often designated single or double type.

The air supply systems may be distinguished as upward and downward systems the former being used in such buildings, as theaters, auditoriums where people are closely associated. Air is supplied near the floor and exhausted through grilles in or near the ceiling. The downward plan is used in school-rooms, hospitals, and other public buildings, air being introduced 8 ft. or more above the floor and drawn out near the floor. The selection of either system depends upon conditions confronting the engineer.

The amount of heat to be supplied can be determined as outlined in Chapter I and briefly stated amounts to the losses from transmission, from infiltration, with proper allowances for heat supplied by persons or processes. Temperatures usually specified for various types of buildings are to be found in Table 1 (p. 6).

The amount of air to be supplied depends largely upon the type of service required, the amount of heat needed, the perfection of ventilation

[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.

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 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.)

The mean temperature t_2 of the air leaving the indirect radiator (blast heater, tempering coil, reheater, unit heater or gravity indirect radiator) should be learned from the makers, tables for the heater or indirect radiator or heater it is proposed to use.

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, $t_1 = t$; $M = \dfrac{H}{0.24\,(t_y - t)}$ ---(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, $t_1 = t_o$ $M = \dfrac{H}{0.24\,(t_y - t)}$ ---(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 $M_r = \dfrac{H}{0.24\,(t_y - t)} - M_o$ ---(4)

The mean temperature of the air entering the indirect heater is ascertained by the following formula:

$$t_1 = \frac{M_o\,(t_o + 460) + M_r\,(t + 460)}{M_o + M_r} - 460 \quad \text{---(5)}$$

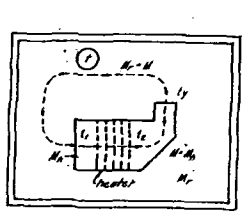
Case 4—When all of the air circulated is drawn from the outside and passed through a tempering coil, air washer or humidifier and reheater.

The temperature of the air t_1 entering the reheater will have the same dewpoint 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.

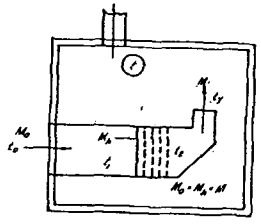
A relative humidity of 35 per cent for a room temperature of 70 deg. has been selected because this is the highest percentage of moisture which the air can hold without producing dripping on single-thickness windows in cold weather.

In this case: $M = M_o = M_h = \dfrac{H}{0.24\,(t_y - t)}$ ---(6)

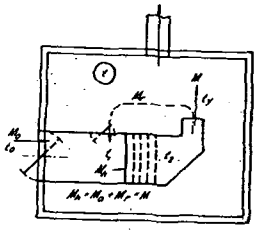
If it is desired to maintain a room temperature of 70 deg. with 35 per cent relative humidity from an outside temperature of zero and with simply an air washer without



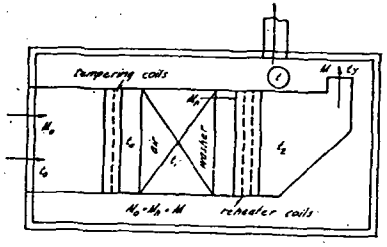
Case 1



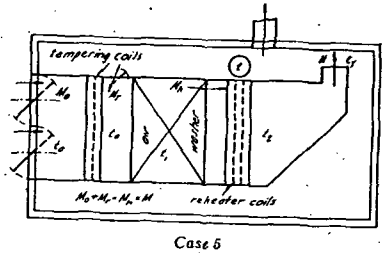
Case 2



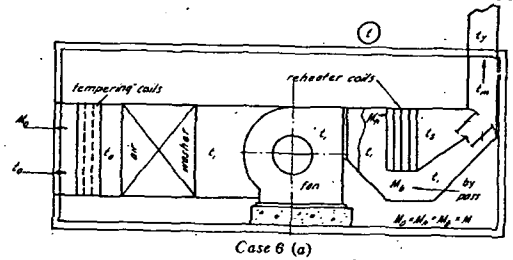
Case 3



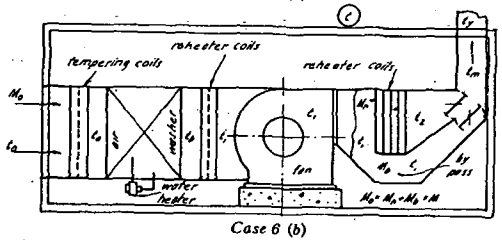
Case 4



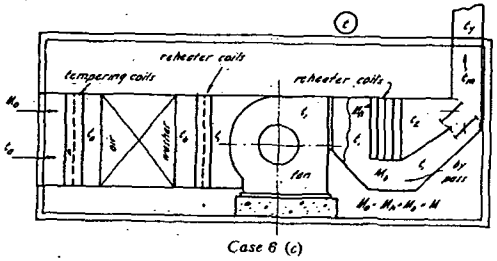
Case 5



Case 6 (a)



Case 6 (b)



Case 6 (c)

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 dewpoint temperature of the air leaving the air washer and in the room itself will be 41 deg.

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 tempearture 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 this 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 this 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 formula:

$$M_o \times 0.24\ (t_y - t) = H \qquad (8)$$

$$t_y = \frac{H + 0.24\ M_o t}{0.24\ M_o} \quad \text{.....(9)}$$

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 dewpoint 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

$$(X)\ (t_2 + 460) + (1 - x)\ (t_1 + 460) = (t_m + 460) \quad \text{.....(10)}$$

t_m = Mean tempearture 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.

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 foot per minute.
2. Static pressure of system (ducts, heaters, air washers, filter, entrance connections, etc).

The kind of fan will depend upon the service required, disc and propeller fans being used generally where no resistance is built up. In ventilation work centrifugal fans are largely used and these come under two classifications—those with straight radial blades and those with curved blades. Each type of fan has its special applications and there is a definite relation between its pressure characteristics, power requirements and the service rendered. Where noise is not objectionable, fan efficiency is the governing factor. In places where quiet operation is essential proportionate outlet velocities should be chosen (see Chapter XIX).

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.

It is well to remember that good practice requires that:

1. The mechanical efficiency of a centrifugal should exceed 55 per cent.
2. Air velocity passing thru the fan outlet should not cause excessive noise.
3. The fan should operate silently and not transmit noise to ducts.
4. The use of variable speed motors is advisable to meet changes in frictional resistance, power economy when ventilation demands vary while constant speed motors are less expensive when ventilation requirements remain uniform.

A fan installation rightly designed and operated will be quiet and efficient but every precaution should be taken to prevent vibration or sound passage to the rooms. The method of fan drive is important, the insulation of motor, and fan foundations with felt, cork and other approved materials of adequate thickness properly waterproofed.

UNIT SYSTEMS*

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

Data on Unit Systems contributed by H. B. Hedges, New York, N. Y., G. E. Otis, Moline, Ill., and A. J. Nesbitt, Atlantic City, N. J.

industrial installations. They differ in design and construction in proportion to the service for which they are intended.

They may be located in the various rooms or parts of a building for discharging warmed air into the room or building, and either entirely or partially recirculating the air, or else having a fresh-air connection for special ventilation purposes. These units, in the case of a school-room and sometimes in factories, are set on the floor but frequently in factories are suspended from the roof trusses so as to leave the floor spaces unobstructed.

Public Building Work

Unit heating and ventilating systems intended for public building work consist 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 XIII.)

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 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 air is driven from the machine in a vertical direction at a velocity ranging from 800 to 1000 ft. per minute. This high velocity drives the air against the ceiling of the room, thereby diffusing it and spreading it in a downward movement to all parts of the room.

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 ventilator. This is not necessary but it has been proven a very satisfactory location and where vent flues are used it is advisable to locate them on inside walls to prevent downdrafts.

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 class-rooms and wardrobes, outlets from latter must be at floor.

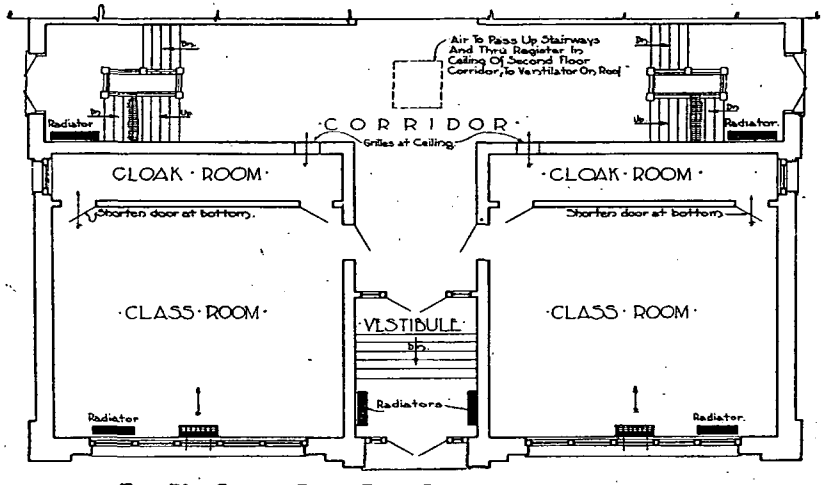


FIG. 76. SCHOOL ROOM PLAN SHOWING LOCATION OF UNITS

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 cases where state laws have failed to anticipate this system of ventilation and demand larger vent flues, arrangements can usually be made to provide throttling dampers in same to secure the desired effect.

The so-called corridor system of venting is frequently employed with unit ventilators and is favored by many engineers with this system of ventilation. Vent flues are dispensed with and room outlets are directly into corridors, which serve for conducting the air to roof ventilators connected with grilles located in the ceiling of the top story corridor.

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 min. with this type of apparatus, for this reason mechanical unit ventilators are not built with capacities greater than 1500 cu. ft. per min. and should never be used except in rooms with very high ceilings. In a practical way this determines the number of ventilators 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 min. per foot of ceiling height.

Mechanical unit ventilators should be centrally located 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 jet action 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 B.t.u. required for heating and ventilating 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 did not exceed 20 sq. in. per 100 cu. ft. of air.

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 distributed 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. If the unit could always be located in the center of the area, which is the most ideal location from a standpoint of distribution, then one unit would most generally be capable of heating an area from 50 ft. square up to an area 150 ft. square.

Unit heaters may be divided into two classes: Namely, the Direct Fired Type and the Heating Coil Type.

The Direct Fired Type is constructed very much along the lines of the pipeless furnace used in house heating and burns coal, coke, wood, oil or gas fuel. A power driven fan connected to the base of the heater creates

TABLE 100. B.T.U. CONSTANTS FOR VARIOUS STEAM PRESSURES AND TEMPERATURES OF ENTERING AIR

STEAM PRESSURE LBS.	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.

a rapid circulation of air over the cast iron heating surface provided in the fire box. The air thus heated is discharged into the building from an outlet on top of the heater. Generally this type is used where steam or hot water is not available and where it is not desired or practical to install a boiler plant.

The Heating Coil Type unit heater consists of a bank of steam or hot water heating coils which may be made of steel pipe, cast iron, copper or brass over which air is blown or drawn by means of a power driven fan. The fan may be direct connected to the motor or pulley driven from motor or line shaft. This type Unit has two distinct classifications: Namely, the Horizontal and the Vertical types.

The Horizontal type as a general rule uses a propeller or disk fan for passing the air over the heating surface. Cast iron and copper tube heating surface are in most cases used in this type unit. The fan and heater are built into a sheet metal casing and the direction of flow of air is regulated by means of sheet metal baffle plates. An advantage of the Horizontal Unit is that it is comparatively light and can be suspended from columns or trusses of the building, thus conserving the floor space,

and allowing return mains to be run overhead. The individual motor power requirements per unit are usually less than for other types.

The Vertical Type, as is implied by its name, provides for the air to enter near the floor level and pass vertically through a bank of steam or hot water heating coils. Movement of the air is produced by a power driven fan, and a sheet metal distributing outlet at the top directs the distribution. While this type unit is quite frequently suspended from overhead structural supports, it is primarily designed to rest on the floor level, from which position the most effective results are obtained.

The fans are of the multi-blade centrifugal type and are capable of operating against a static pressure of 1 in. of water or more.

When placed on the floor level these units take the air in at the lowest point where the air is coldest and discharge the heated air at a distance of from 8 to 12 ft. above the floor. The discharged warm air is dissipated in the space to be heated and as it cools, falls to the lower level and is again taken in at the base of the unit and reheated. When so desired the units may be provided with a fresh air connection so that either all outside, all inside, or a combination of both may be used through the heater. This arrangement proves most satisfactory for producing a circulation of outside air in the summer time for ventilation purposes, particularly in large open industrial buildings such as; machine shops, textile mills, foundries, warehouses, garages, mills, railway shops, armories and gymnasiums.

CHAPTER XIX

DESIGN AND CONSTRUCTION OF AIR DUCTS

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 the mechanical circulation of air, or by gravity, 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 asperating 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 buildings, where freedom from noise and elimination of drafts is essential and where branch ducts serve individual rooms, is a much different problem in design than that 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 the difference in operating expense.

Standard velocities of air in public buildings are as follows:

1. Through the outside air intakes 1,000 ft. per min.
2. Through connections to and from heater 1,000 to 1,200 ft. per min.
3. Through the main discharge duct from 900 to 1,200 ft. per min.
4. In branch ducts 700 to 900 and vertical flues 400 to 600 ft. per min.
5. In registers or grilles 200 to 400 ft. per min. depending upon the size and location.
6. If diffusers of proper design are used, 25 per cent higher air velocities may be permitted.

Material for this section was prepared by F. R. Still, vice-president American Blower Co., New York.

TABLE 101. 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

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) uniform air delivery through outlets is accomplished, (2) friction in smaller pipes is reduced, (3) portion of velocity head is converted into static pressure.

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 in pressure in inches of water gage as per Table 101.

Friction losses due to friction of air against sides of ducts, vary directly as the length of the pipe, directly as the square of the velocity and inversely as the diameter. Friction is commonly expressed as equivalent pressure in inches water gage or in terms of velocity heads, (the ratio of friction loss to the theoretical pressure corresponding to the velocity in the duct). One velocity head is the pressure corresponding to the velocity of air in the duct.

For smooth round pipes the friction loss is:

$$F = \frac{L}{50\,D}\left(\frac{V}{4005}\right)^2$$

where

F = loss of pressure in inches of water
V = velocity in feet per minute
L = length of pipe
D = diameter of pipe in feet; $\frac{L}{D}$ = length of pipe in diameters.

If a factor of safety is thought desirable the length 45 may be used though experiments show that the friction loss is equal to one velocity head in a length varying from 40 to 60 diameters depending upon the smoothness of the duct. The engineer's judgment and experience should prevail in this matter. For example correction should be made for pipes with rough or uneven surfaces and in the case of brick or concrete ducts the friction loss should be increased 25 per cent or more.

A formula for rectangular ducts is derived in a similar manner but it will be found very convenient to use the accompanying chart Fig. 77.

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 $\frac{1}{3}$ to $\frac{1}{2}$ and the loss through heater at less than $\frac{1}{2}$ 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.

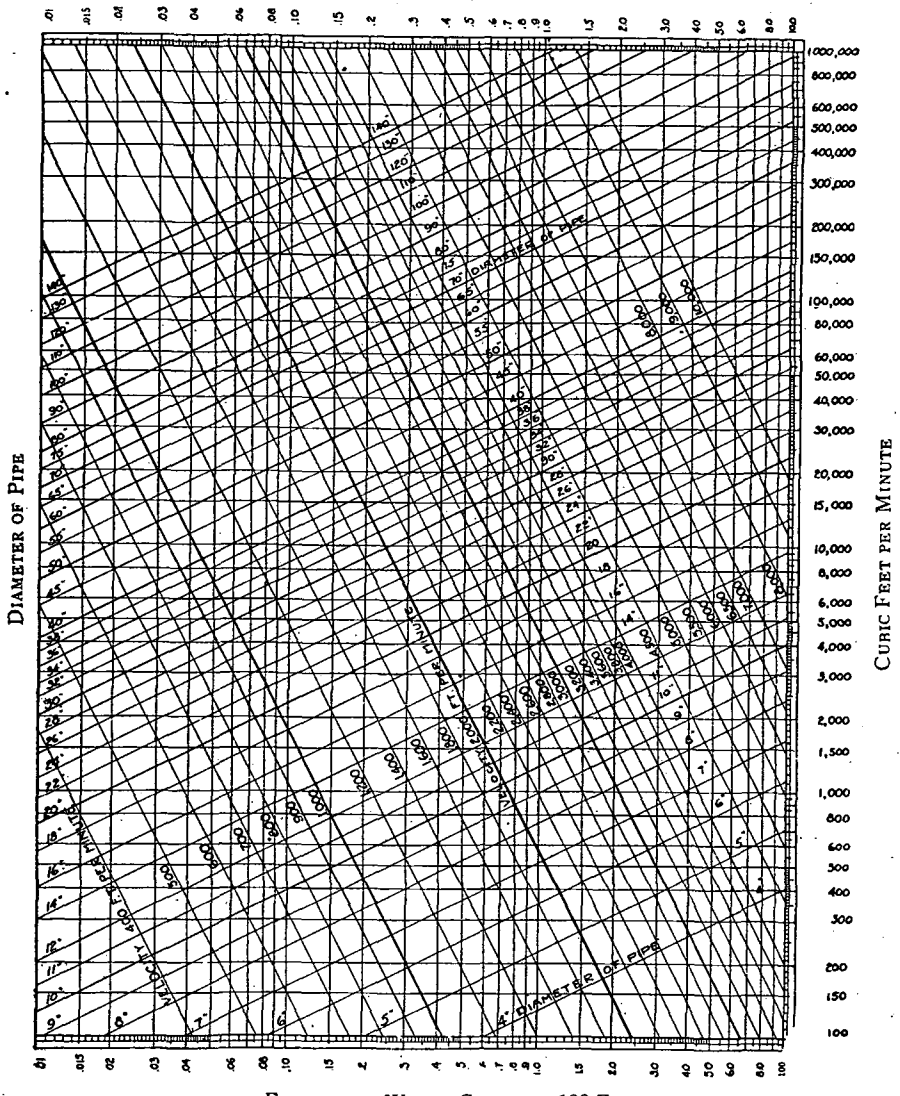


FIG. 77. FRICTION CHART

HOW TO USE THE FRICTION CHART

While this chart can be used to determine the friction of air which is flowing through ducts, it can also be used for determining the size of a pipe to handle a specified volume or the velocity that will be necessary. For example:

1. Assume that a volume of 20,000 cu. ft. per min. is to be discharged through a 36 in. duct. The volume is given on the right hand margin; follow along the horizontal line opposite 20,000 cu. ft. per min. until it intersects with the diagonal line sloping upward to the right which is marked 36 in. diameter of pipe. The velocity will be found to be 2,800 ft. per min., this being the other diagonal line sloping downward to the right. At this point of intersection is a vertical line giving the friction, which is indicated at the bottom of the chart as being 0.4 *in.* water gage per hundred feet of length. Thus if the duct is only 40 ft. long, the friction will amount to $\frac{40 \times 0.4}{100} = 0.16$ in. W. G.
2. The friction of elbows varies with the radius; an elbow having a radius in the throat that is half the diameter of the pipe, will present a frictional resistance that is equivalent to a straight pipe that is 30 times its diameter. For instance a 36 in. diameter elbow having a radius of 18 in. in the throat would present as much friction as $\frac{30 \times 36}{12} = 90$ ft. of straight 36 in. pipe.

   If the radius in the throat is equal to the diameter then the friction would only be equal to 10 diameters. If the radius is twice the diameter, the friction is only 4.3 diameters.

   The friction of a rectangular pipe for a given velocity (not for volume) can be converted to an equivalent round pipe as follows: $D = \frac{4\,W\,H}{2\,W + 2\,H}$, in which W is the width, H is the height and D is the diameter, all in inches.

   To find an equivalent diameter for a given volume and the same friction as a rectangular duct, proceed as follows:

$$D = \frac{W}{0.79 \sqrt[5]{\left(\frac{W}{H}\right)^2 + \left(\frac{W}{H}\right)^3}}$$

SOME GENERAL INSTALLATION AND CONSTRUCTION HINTS

1. Ducts should be not less than 6 x 6 in. in size and made of galvanized iron or steel.
2. Angular turns should be made with elbows having a radius not less than the width or diameter of the duct.
3. Offsets should be at an angle of 30 to 45 deg.
4. Branch ducts should make curved connection with main duct and should have accessible dampers.

GAGES OF GALVANIZED IRON OR STEEL TO BE USED FOR DUCTS, FOR OUTSIDE AIR INTAKE

Heating and Ventilating

ROUND DUCTS, DIAM., IN.	GAGE	RECTANGULAR DUCTS WIDTH, IN.	GAGE
6 to 19	26	4 to 18	26
20 to 29	24	19 to 30	24
30 to 39	22	31 to 60	22
40 to 49	20	61 to 118	20
50 and above	18	118 and above	18

5. Rectangular ducts should have metal strap or rod supports and when over 36 in. in width should be stiffened with angle iron at 4 ft. intervals.
6. Longitudinal seams and transverse joints should be flat and smooth inside; slip joints should be in direction of air flow.
7. Access doors to ducts should be hinged and fire dampers in supply and vent ducts should be of ⅛ in. steel plate, held by fusible link for release at 160 deg. fahr.
8. Air intake should be screened with 1 in. mesh or less and protected from weather.
9. Final exit for exhaust ducts should be protected from weather and placed so as not to contaminate air supply.
10. Underground ducts should be waterproofed, drained and provided with means of access for inspection and cleaning.

MEASUREMENT 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 min. 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 XX

AIR WASHERS AND FILTERS

THE cleansing of air for ventilation purposes is a very important phase of the art and is accomplished by two different means; washing and filtering. Both methods cleanse the air of solid or liquid matter in the form of dust or spray, while in addition the washer cleanses the air of soluble gases and vapors, and hence of many objectionable odors.

Air filters are distinguished from air washers in that they clean the air without the use of water or the addition of water vapor. They are of two types (1) the viscous filter depending upon the dirt impinging on surface covered with a viscous fluid or oil; (2) the true dry filter type which removes the dirt from the air by passing it through cloth or felt screens, the openings in which are too small to allow the passage of dirt.

TYPES OF AIR WASHERS

The washing of air is done by passing it over a large surface area of water which is accomplished in the various types of washers; (1) by passing it through a fine spray of water; (2) by passing it over 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 very low temperature the washer becomes a dehumidifier or by heating the water the air may be humidified. 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 6 deg., the humidfying efficiency is

$$E = 1 - \frac{6 \text{ deg.}}{20 \text{ deg.}} = 0.70$$

Material prepared especially for THE GUIDE by W. H. Carrier, Carrier Engineering Corp., Newark, N. J.

TEMPERATURE AND HUMIDITY CONTROL

Air washers require method of control of temperature to prevent freezing by too low temperature and of overhumidification by too high temperatures of the air entering and leaving the washer. There is available one method of hand control and five methods of automatic or semi-automatic control. The method of hand control is by tempering coils divided into two or more sections in series; the outer coil being turned on by hand whenever the outside temperature approaches freezing; the successive coils 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 the third section, where provided, at temperatures below zero. The first, or outside section, must always be turned on full for all temperatures to prevent freezing of the coils. The steam supply to the second, or inside section, may be hand regulated at all temperatures above 10 deg. above zero.

The five systems of automatic regulation are:

1. Substitution of automatic regulation for hand regulation and operated in a similar manner; the coils being controlled both by variations in the outside temperature conditions and also by an auxiliary control for one inside coil from a thermostat located on the discharge side of the air washer. (It is not possible 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 coils before coming 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), between 35 and 40 deg. of the air leaving the washer. This method does not necessarily require a tempering coil, it is preferable, however, to use one tempering coil for the purpose of tempering the air should the washer be shut down and prevent freezing of the water when the apparatus is not in operation. More than one tempering coil should never be used except where temperatures may go considerably below zero, then the tempering coils may be turned on, one at 20 deg. fahr. and the second at 0 deg. fahr. The tempering coil 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 from 10 to 35 deg. fahr., when water heating is used in conjunction with a tempering coil. This is to allow for sufficient margin for safety of operation. The steam requirements for this are given later.

3. By regulating the heat supplied either through tempering coils 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, it is a fairly effective and simple control. 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 coil. 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 coils 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 effectively prevents overhumidification and also danger of freezing and prevents the highest economy in cost in ventilation 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 thermostatic controlled temperature and to control the relative humidity of the air by means of a hygrostat which operates either on the tempering coils to heat the air or to heat the spray water through a water heater.

STEAM REQUIREMENTS FOR AIR WASHERS AND FOR HUMIDIFICATION

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 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.h.p., for every 3400 cu. ft. of air per min. These are the minimum requirements for humidication above that required for heating the air. The following Table 102 gives the heat required from various outside entering wet bulb temperatures to various dew points temperatures corresponding to a relative humidity of 70 deg.

TABLE 102. HEAT REQUIRED FROM VARIOUS OUTSIDE ENTERING WET BULB TEMPERATURES TO VARIOUS DEW POINT TEMPERATURES CORRESPONDING TO A RELATIVE HUMIDITY OF 70 DEG.

See Mark's 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

These values are for the total heat required for both heating and humidifying the air. The amount of heat required for humidfying only may be found by subtracting from the values given the heat required to raise the temperature of 1000 cu. ft. of air per min. between the limits specified. The heat required for heating the air is given by the formula

$$H = 1000\,\frac{t_2 - t_1}{55.5}$$

DUST REMOVAL

The comparative efficiency of various air cleaning devices, on the basis of dust removal can be determined by means of standardized tests operated at rated capacities and when handling air at a definite standard

with respect to quantity and quality of dirt content. The determination of the cleaning efficiency may be made according to some standard method such as that described by A. M. Goodloe, member, A. S. H. & V. E. in the February 1924, JOURNAL. The percentage of dust removal as determined by the method of testing for all commercial air cleaning devices should lie between 80 and 95 per cent and the minimum removal under such conditions should be specified and guaranteed by the manufacturer.

The efficiency of dust removal may be expressed by the following formula:

$$E = 1 - \frac{\text{Weight any sample leaving}}{\text{Weight any sample entering}}$$

In case the resistance method is used in accordance with the Anderson-Armspach method of dust determination, the formula will become

$$E = \frac{\text{Time required to give a definite resistance increment with entering sample}}{\text{Time required to give the same increment with leaving sample}}$$

or, if the same time be used in obtaining both samples, which is preferable then

$$E = 1 - \frac{\text{The resistance increment of outgoing sample}}{\text{The resistance increment of ingoing sample}}$$

RATING OF AIR WASHERS AND FILTERS

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 washer or filter 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 washer while operated at its rated capacity.

5.—If considered as a humidifying agent, the humidfying efficiency, or the percentage of reduction in the initial wet bulb depression without external alteration of heating the circulating water.

CHAPTER XXI

AIR CONDITIONING AND COOLING

THE temperature and humidity of the air that surrounds people has an important bearing on their comfort and general efficiency while in the industrial field hundreds of manufacturing operations are dependent for their success upon the atmospheric conditions maintained. Geographical location has a bearing on climatic conditions and an intensive study of temperature and humidity variations in different localities shows that the places having a 56 deg. fahr. wet bulb temperature are favored with best health conditions, the greatest progress in science, art and mechanical development.

Scientists have always been seeking a way to produce the same ideal conditions indoors that prevail outside at certain seasons of the year. Many studies have been made, numerous theories have been advanced and discarded. From the latest studies of human comfort (see Chapter XVII) it has been concluded that there is a definite relation between a person's feelings and the degrees of heat, humidity and air motion.

Air conditioning as it is practiced today means to obtain predetermined effects upon material or persons within an enclosure by controlling the air purity, temperature, humidity, distribution and movement.

The development of effective devices for producing and maintaining the ideal atmospheric conditions desired, has made tremendous strides in the workroom and factory, school, theatre and hotel while but little effort has been made to reproduce these conditions in dwellings.

The manufacturer has adopted air conditioning as it has become an exact science and the results are measurable in dollars and cents, in a more perfect product, an increased production, elimination of waste or 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 and textile mills, printing plants, bakeries, candy kitchens, laundries, etc., all present 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 and 50 per cent relative humidity give a high quality product. In some cases humidity must be supplied in others dehumidifying is necessary.

Air has certain definite properties and obeys certain well known laws, therefore to handle problems in air conditioning the relation between the wet and dry bulb temperature and the dewpoint should be thoroughly understood by the engineer. Briefly, the dewpoint is the temperature at which saturation is obtained for a given amount of water vapor. With air at the dew point the wet and dry bulb temperatures are the same. If

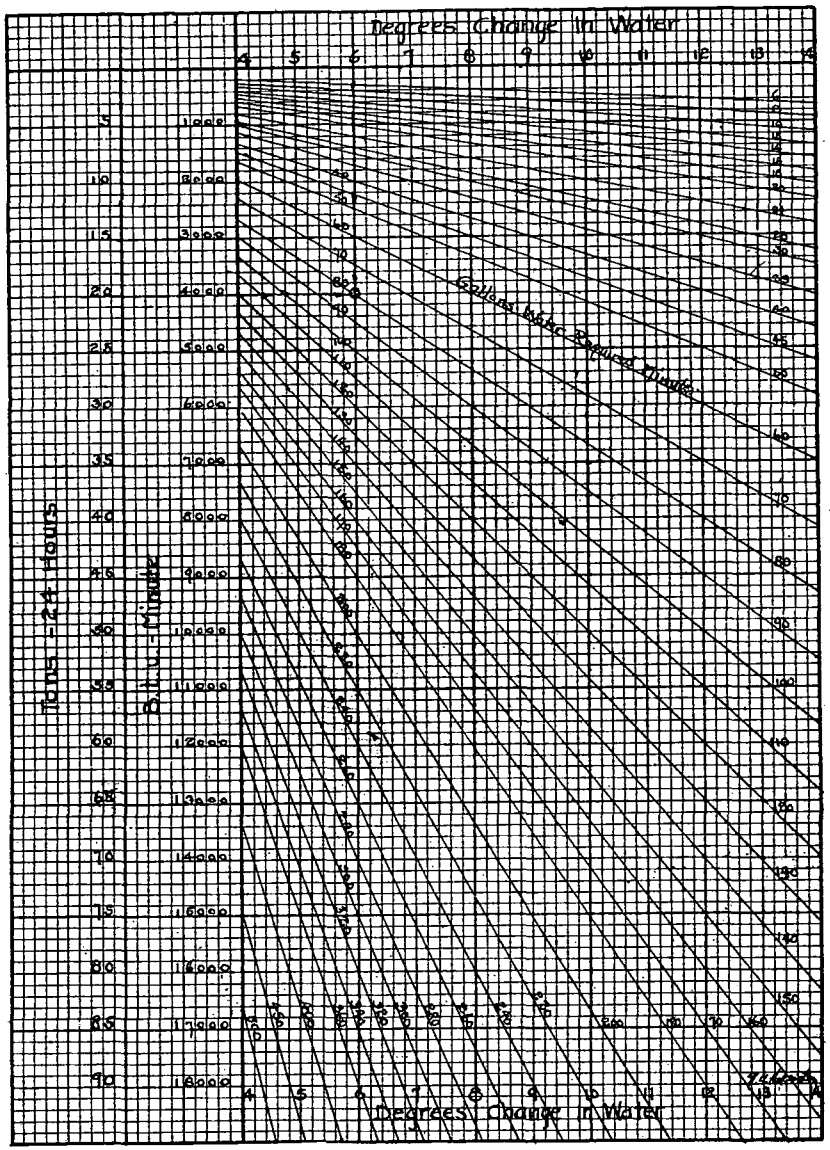


FIG. 78. GALLONS WATER REQUIRED PER MINUTE

heat is applied to air saturated at 50 deg. both thermometers will rise, the wet bulb more slowly and the relative humidity will be reduced. At ordinary temperatures the absorption of 1 grain of moisture per cu. ft. reduces the dry bulb temperature 8½ deg.

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, in the average dwelling little attention is paid to these items 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 problem, 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

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. Fewer coils required, therefore lower first cost, less space and weight
2. Low power for driving compressor
3. Ease of keeping unit clean
4. Ease of controlling effect on air
5. Securing of air cleaning
6. Humidity control in winter

*Section on Cooling with Refrigeration compiled especially for THE GUIDE by N. A. Hollister, New York, N. Y.

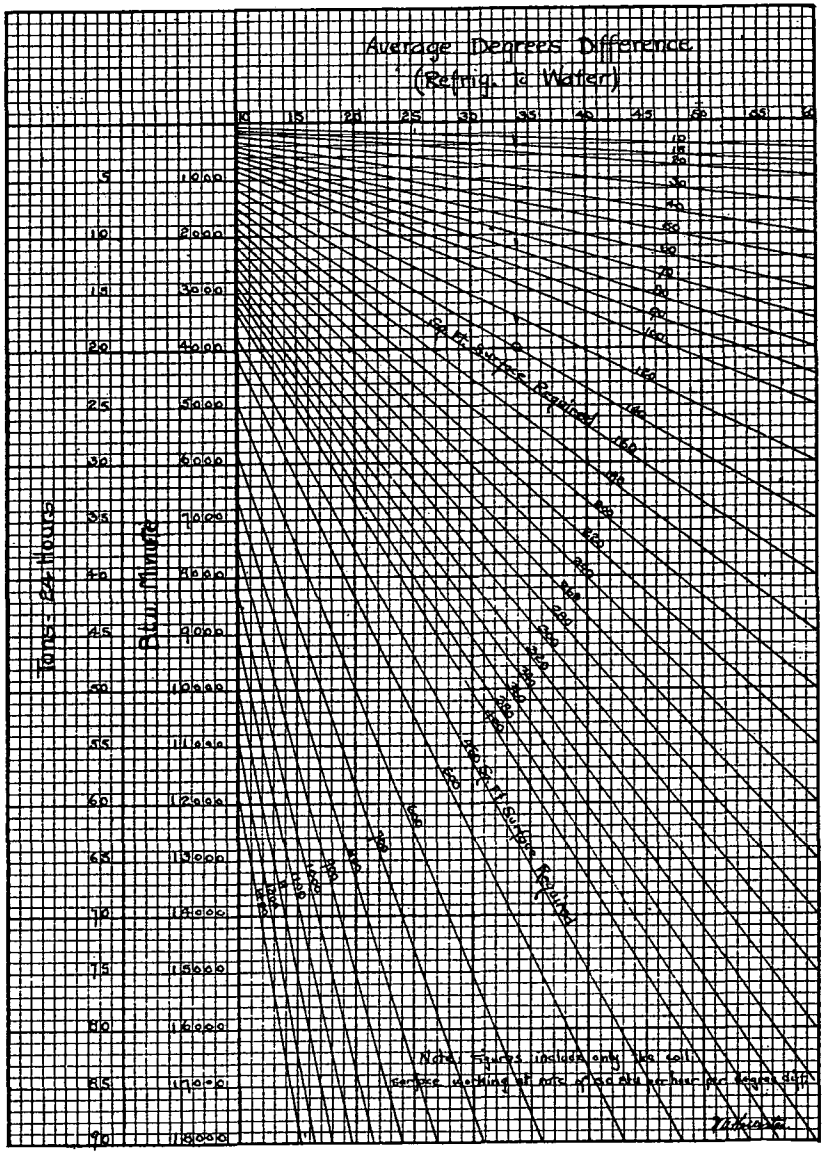


FIG. 79. SQUARE FEET WET COIL SURFACE

LESS COIL REQUIRED

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. A liquid spray has the following marked advantages:

1. Cheap method of securing an enormous radiating surface for heat transfer from the air
2. Continuous cleaning radiating surface
3. Elimination of all frosting of the coils with the accompanying lowering of heat transfer from coil surface
4. High heat transfer from liquid to coil surface

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 will make a heat transference which would require a large and expensive coil.

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.

LOW POWER FOR DRIVING COMPRESSOR

Many air conditioning installations are operated 24 hours per day and on every installation the power used for operation is important. The higher the ammonia temperature, the lower the power used by the compressor.

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.

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

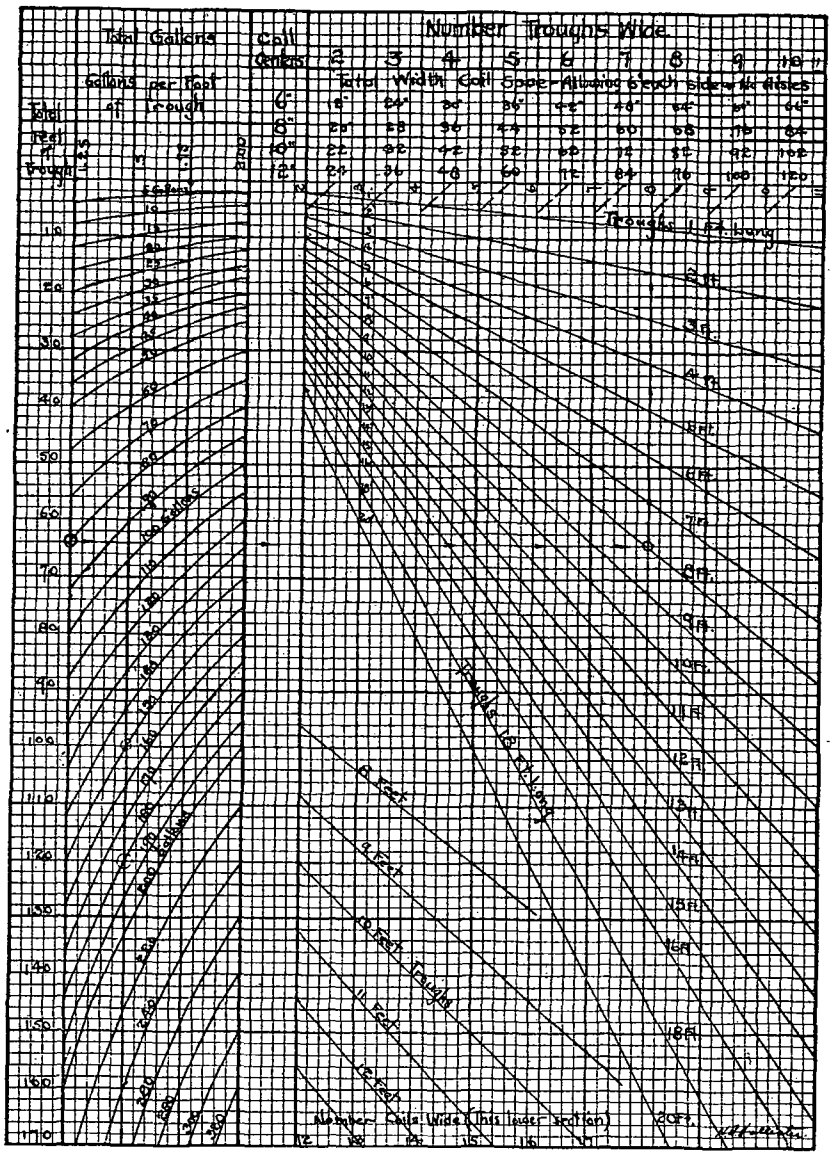


FIG. 80. TROUGHS

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 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 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 re-circulation or by heating the water or by both, even an excessive humidity may be readily 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.

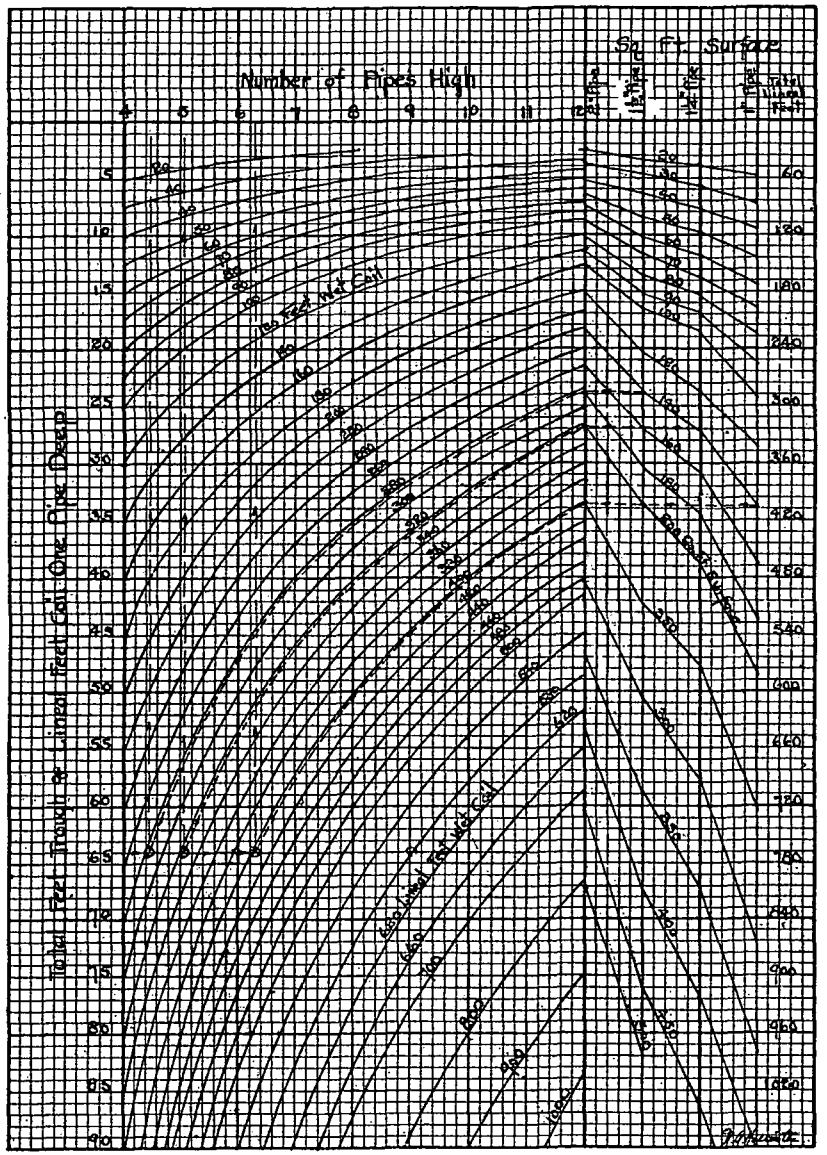


FIG. 81. SIZE OF PIPES AND NUMBER OF PIPES HIGH

TABLE 103. CUBIC INCHES OF AMMONIA VAPOR TO BE CIRCULATED TO PRODUCE ONE TON OF REFRIGERATION IN TWENTY-FOUR HOURS

CONDENSER PRESSURE		Gage	95	110	123	140	155	170	185	200	215	230	245
		Abs.	100.7	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

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 refrigeration. 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.

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. 78 shows that 80 gallons water per minute are required.

Fig. 79 shows that 140 square feet 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. 80 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. 79 and 80 it was found that 140 sq. ft. of surface and 64 lineal feet of troughs were required. Fig. 81 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. 78, 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 diningrooms, theater 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 outlined in Chapter XV. Unless artificial cooling is resorted to it is hardly possible to obtain better than 75 per cent perfection as outlined in Chapters XV and XVI 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 XXII

DRYING

DRYING is an extraordinarily interesting problem in engineering, and thousands of the products that we 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 our 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 sensatized becomes photographic film. All textiles require the drying process at sometime during their manufacture.

The term drying is often used to cover dehydration, distillation, oxidation, evaporation or any chemical action due to each of these conditions. Drying in its broader sense is not confined to the removal of moisture alone, but may refer to the evaporation or removal of substances other than water and to such operations as paint and varnish drying, linoleum manufacture and many other materials which require special treatment with respect to temperature, relative humidity and rates of moisture removal.

METHODS OF DRYING

In general, drying processes may be divided into three classes: vacuum drying, drying with radiant heat, and drying with air currents.

The vacuum method is particularly adapted to material which must be dried quickly at low temperatures and is generally used in the drying of milk, sugar, vegetables and similar products.

In drying with radiant heat the temperature of the material being dried is above that of the air surrounding it. The uniform distribution of radiant heat is important in the proper drying of materials, and the radiator used should have relatively large radiating surface and be well distributed in the drying area. About one-third to one-half of the heat given off by the 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 emitted by the radiator warms the air by convection and produces air currents which assist in the removal of the moisture from the material being dried.

Drying with currents of air or air processing as this method is usually termed, depends for its success upon the proper circulation in the drying chamber so that it will come into direct contact with the substance to be dried. In ordinary work air temperatures carried are from 70–200 deg. fahr. with a relative humidity of 90–50 per cent. When temperatures exceed 200 deg. the process is referred to as high temperature

drying. Low temperature dryers are heated either by steam or hot water directly or indirectly and the temperatures are below the boiling point. In high temperature dryers the range is above the boiling point and the heat is maintained directly or indirectly by electricity or heated oil, direct introduction of flue gases, by high pressure steam or special air heaters. Dryers are usually termed intermittent or continuous, depending on whether they are charged for the complete drying period of whether the material to be dried is continuously admitted and removed. As compartment dryers consist of an enclosure to direct the air movement and control the heat, the current of heated air flowing through the drying cabinet is under accurate and uniform control of temperature and humidity. The selection of the compartment or continuous type of dryer depends upon the most practical method of handling the material rather than upon the drying process. The use of the continuous dryer is customary whenever the drying period is less than 6 hours or where the continuous drying process is required for 24 hours at a time. The efficient operation of the continuous dryer requires that it function at full capacity. The continuous dryer will be found in a variety of forms those principally used being the tunnel, drum, rotary and spray types. In a tunnel dryer the product being kept in trays or loaded on cars moves along by gravity or by means of an endless belt conveyor and the air usually moves in the opposite direction from the material in order to get the maximum drying efficiency. Drum dryers are used for liquids or solids such as paper, cloth and materials that will pass over the drum in a continuous sheet.

A rotary type of dryer consists of revolving drums through which material and air intermingle, the drum being inclined to facilitate the movement of the material and is generally used where the product to be dried is in a moist or semi-moist condition. Spray drying consists of sending a fine solution of the material into a current of warm air and is limited to products which can be handled in liquid form.

The relative advantages of the different types of dryers are dependent on the nature of the material, the space available and the capacity of the apparatus.

The variety of the products to be dried include many of animal or vegetable origin and many possess exceptional hydroscopic or absorptive properties. When they are of colloidal nature, successful processing is more difficult. Frequently it is necessary to expose the material to a series of different conditions beginning with a minimum temperature and maximum humidity, the temperature being increased and the relative humidity decreased as the work progresses. Where material contains both free and hydroscopic moisture, humidity conditions must be carefully adjusted so that during the period when the free moisture is being removed case hardening or surface drying does not occur. The air circulation is another important factor and the velocity which is used should be high enough to constantly remove the heavy film of saturated air which surrounds the material as soon as it begins to dry.

The temperature in which a product is to be dried should be as high as can be used without injury to the material. The accompanying tabulation will give the conditions that are usually found satisfactory.

Material	Temp. Deg. F.	Time
Apples	140–180	6 hours
Cocoanut	175–200	4–6 hours
Sugar	150–200	20–30 minutes
Coffee	160–180	24 hours
Mixed Stock Feed	220	20–30 minutes
Starch	180–200	12 hours
Glue	70–90	2–4 days
Thin Leather Hides	90	2–3 days
Thick Sole Leather	90	4–6 days
Shade Cloth	240	1–2 minutes
Rubber	80–90	1–2 weeks
Soap	100	2 days
Wall Board	200–250	12–24 hours
Gypsum Board	180–280	24–48 hours

In any system where there are no critical temperatures the permissible maximum working temperature is that above which the actual gain in speed or output due to the increase temperature is less in proportion than the increase speed of operation due to the increased temperature. In the case of some fruits and vegetables a relatively low temperature and high velocity is better than too high temperature, but, a too low temperature and too long drying period result in a tough product.

The evolution of the compartment and tunnel dryer design is very interesting and inumerable means have been used to secure the proper heating effect, air distribution and moisture removal. In dryer design it should be noted that there are three important objectives to be attained: to secure an adequate supply of air so distributed that it circulates evenly over the radiators and trays; to secure a rapid air movement so that moisture is absorbed from the material to be dried, and to effectively remove the moisture from the saturated air. The quantity of air that should be supplied by the fan and the number of air changes in the drying compartment will vary with the type of installation and is affected by the rate at which moisture is given up by the material to be dried.

The theoretical amount of moisture which the air will remove is directly proportional to the difference between the wet-bulb and dry-bulb temperature of the entering air, while the actual amount absorbed by a given quantity of air is measured by the drop in dry-bulb temperature between the air entering and leaving the dryer, less a slight correction for radiation. For the same reason the higher the temperature of the entering air (for a given initial moisture content) the greater will be the amount of moisture removed per given quantity of air and the greater the economy of the dryer.

The temperature of the air will drop approximately 8½ deg. for each grain of moisture absorbed per cu. ft. of air measured at 70 deg., or 0.64 of a deg. for each grain of moisture absorbed per pound of air. Approximate calculations may be based on air volume, but for eaxct determinations the weight of air handled should be used, on account of it being a fixed quantity at all temperatures. Knowing the rate of drying desired and the amount of moisture to be removed, it is a simple matter to determine the quantity of air required.

It is generally found that about 2 lb. of steam are required to evaporate

1 lb. of water, under the most favorable conditions, while the more usual figure for steam consumption is 2½ lb. of steam to 1 lb. of water evaporated. The principal losses in air drying are radiation and escape of unsaturated air, either through the usual vent ducts or by leakage through the kiln walls.

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.

It is customary for engineers who specialize in the design of such equipment to treat each problem individually and develop the most efficient for the specific requirements of the client.

REFERENCES

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CHAPTER XXIII

OZONE IN VENTILATION

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 continuoulsy 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.

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

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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 percent 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 & Ventilating Mazagine, 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 inhibatory 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 re-circulated, 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 continuously respired without noticeable effect. (Henderson, Yandell, et al—*Journal. Ind. Hyg.* Vol. 3, 1921). Carbon monoxide has been frequently 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 is 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 & 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 text book of volumetric analysis. A few precautions, not ordinarily described in standard text books, should be observed when applying this method to ozone determinations, see Hartman, F. E., Analysis of Ozone-Air Mixtures, *Aerologist*, August, 1926.

As the out-put of an ozonizer can be very closely controlled by the manufacturer, it is recommended that the out-put 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 out-put 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 co-efficient," which includes the length of the duct system, the heigths 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 & 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:

$$\frac{\text{CFM} \times \text{ppm}}{10^3} \times 56.64 = \text{mpm} \quad \text{.....(1)}$$

Given: mpm and ppm; Find: CFM

$$\frac{\text{mpm} \times 10^3}{56.64} \times \frac{1}{\text{ppm}} = \text{CFM} \quad \text{.....(2)}$$

Given: mpm and CFM; Find: ppm

$$\frac{\text{mpm}}{56.64} \times \frac{10^3}{\text{CFM}} = \text{ppm} \quad \text{.....(3)}$$

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 pounds 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

$$\frac{\text{CFM}}{100} \times \text{ppm} = \text{VU} \quad \text{.....(4)}$$

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 XXIV

DUST, EXHAUST AND COLLECTING SYSTEMS

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. It is, however, more difficult to balance than the central, and also the large number of small diameter trunk lines required show a much higher friction loss per foot of length than with the central system where one large main pipe serves a considerable number of machines.

Exhaust systems are also characterized by the means employed to collect the 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.

Material for this section originally prepared for THE GUIDE by H. M. Nichols, revised by R. E. Shaw, Boston, Mass.

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 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 there 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, should do the required work with a minimum power consumption.
7. In cold climates, 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.

In designing an exhaust system certain quantities must be chosen arbitrarily by the engineer, and the success of the installation depends to a large degree upon his experience and the skill with which he chooses these arbitrary quantities. It is quite possible for an inexperienced designer to lay out a system which may figure out theoretically correct, but the general results may be unsatisfactory.

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 104 to 106, 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 6 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 6 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.

TABLE 104. 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

TABLE 105. 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 106. 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

Velocities commonly employed are: 2,500 to 3,000 ft. per min. 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 3,000 to 4,000 ft. per min. Lead dust, hog waste, pulp chips, etc., 4,000 to 6,000 ft. per min.

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.

The resistance of a round pipe to the flow of air is inversely proportional to the fifth power of the diameter of the pipe. Therefore, handling a given quantity of air through a larger pipe at a lower velocity decreases the frictional resistance very materially and correspondingly decreases the horse-power required at the fan, and thus it is very desirable to keep the air velocities throughout the system as low as possible, consistent with the major requirement that the material must be taken away as fast as made, without clogging the pipes, under the varying operating conditions met with from day to day in the plant.

The static suction required at the hood connections varies from 1 to 5 in. of water. The suction required depends upon many factors such as the relative size of the hoods and connections, kind and quantity of material handled, as well as its physical condition. 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.

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 107. The sum of all these volumes gives the total volume to be handled by the exhaust fan.

TABLE 107. 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

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.

An exhaust system to be effective must remove a certain amount of air from each hood or other connection, and in addition must maintain sufficient velocity throughout the piping system to convey the dust or refuse material to the separator. Any system which is mechanically well constructed and handles the requisite air at the connections and maintains sufficiently high velocities, is an effective system from the standpoint of the work done. However, to keep the operating cost low it is advantageous to do the work with as low velocities as the characteristics of the material will permit. The skilled designer will keep both of these requirements in mind and produce a system which is both effective and economical of power.

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.

A. Suction at the various hoods must be chosen from experience. Loss through the hoods can be calculated by an experienced engineer but may be taken very roughly at one-half the suction.

B. Collector drop in inches of water is given by the following formula:

$$\text{Drop} = C\left(\frac{V}{1000}\right)^2$$

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.

C. 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 108. 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.

The total maintained resistance of the system—or static head required at the fan $= A + B + C$.

SELECTING THE FAN

Having determined the volume of air and static head required, the size of exhaust fan, speed and horse-power can be found by reference to the manufacturers performance tables or charts covering the type of exhaust fan selected.

TABLE 108. 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.

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.

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 nominal size and number of the collector will be the same as the diameter in inches of the main pipe leading to it. The nominal sizes of the different makes of collectors vary greatly, and it is advisable to make sure that a collector is large enough to do the work without excessive pressure drop, irrespective of nominal number or size. 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.



FIG. 84. EXHAUST AND CONVEYING SYSTEM HANDLES WASTE FROM WOOD-WORKING MACHINES

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 possibly.

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 wood-working 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

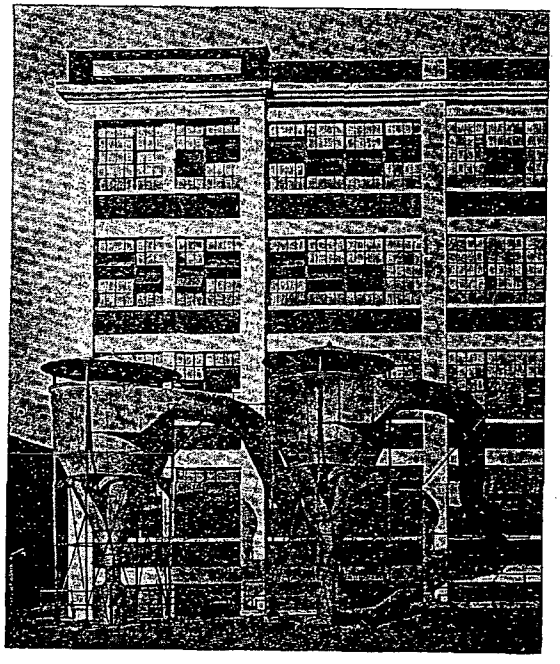


FIG. 85. COLLECTORS ON ROOF PIANO FACTORY

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.

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.

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 XXV

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. Steam jets are reliable, have nothing to break or wear out and are more economical to install. On the other hand fans usually take more power to operate and in cases where fan engines or turbines are used steam can be recovered in the water heater or condensers.

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 operative conditions.

The amount of coal that can be burned per hour per square foot of grate surface is governed by the quality and type of coal as well as the amount of draft available. 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 horse power 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 flue temperature and the size of fan to be provided may be obtained from the maker's table. No attempt should be made to put more air through existing boilers by speeding up the fans as the power consumption will be increased too rapidly. With the fuel bed at constant thickness doubling the weight of air requires about 3½ times the draft pressure difference, and trebling the weight of air about 6 times. Under the first condition the fan would require 6½ times the weight of steam so it can be seen that the most efficient fan must be selected in order for boilers to be driven at a high rating.

The effects of running a fan under conditions other than those for which it is designed are graphically shown by the performance curves of any given fan.

Where the size of the openings and the length of the pipe remain constant the volume of air handled by any fan increases almost directly,

as the speed, the pressure increases as the square of the speed and the power consumed increases as the cube of the speed. It is evident therefore that if more air is required but at an increased pressure it would be better to install a larger or additional fan rather than increase the speed of the present fan.

FORCED DRAFT

In forced draft work the air enters directly to the ash-pit so that the fuel bed is under pressure. Pressure maintained is sufficient to force the air through the duct system, stoker setting and fuel bed otherwise there would be an objectionable leakage of gasses whenever the fire doors were opened. Losses through the boilers, breechings, etc. are cared for by the stack.

Forced draft equipment requires a higher stack than when the induced draft system is used. As the fan handles comparatively cool air the

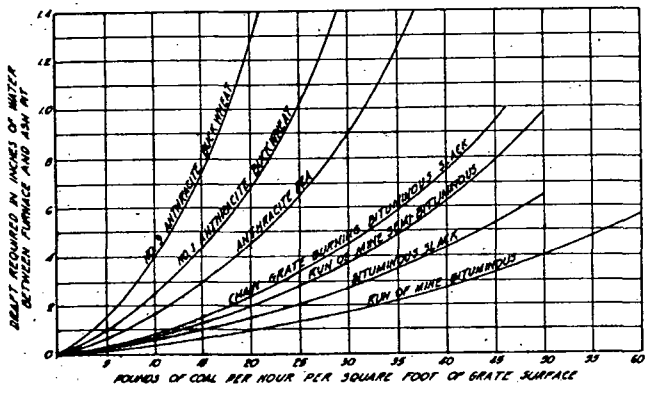


FIG. 86. DRAFT REQUIRED TO BURN VARIOUS KINDS OF COAL

equipment required is smaller and uses less power than an induced draft system of similar capacity.

Forced draft is used in under feed stokers and with chain grate stokers when high peak loads, beyond the capacity available with the natural draft, are required.

INDUCED DRAFT

Fans for induced draft are placed near the base of the stack and handle the smoke and hot gasses leaving the furnace. It is desirable to use this system when an even draft is required and the chimney available is of limited height.

With the practice of providing economizers, air heaters, etc. in the modern boiler plant and operating up to 400 per cent rating an excessive load is placed upon the chimney and induced draft equipment is necessary.

A good idea of the draft needed to burn various kinds of coal at the rate indicated under normal conditions is shown in Fig. 86. Draft for

various loads varies with the combustion rate and with the kind of fuel used. The principal losses which the draft will have to overcome will be through the boiler, fuel bed, the stokers, brick work, breechings and economizers.

The amount of air required with the forced draft system will depend upon the size of the plant and will necessitate the assumption of the combustion rate and the evaporation. There are theoretically 12 lb. of air required for the combustion of 1 lb. of coal, actually the requirements are from 20 to 25 lb. per pound of fuel.

It is customary in mechanical draft work to allow for 100 per cent excess air for hand-fired installations and 50 per cent excess where a stoker is used. This, however, is affected by the kind of stoker used, the size of the installation and the rating it carries. As there is a definite relation between the analysis of flue gases leaving the boiler and the quantity of air supplied, the results of an analysis will give the amount of air or gases being handled by a forced or induced fan. The method used is usually the Orsat apparatus. The amount of air being used may be determined by taking CO_2 readings in the breeching or forced draft connections, or by weighing the coal and ash and taking a flue gas analysis.

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 gauge and will decrease toward the rear as the fuel bed gets thinner.

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 duct for forced draft work should be as short and straight as possible and designed so that the maximum velocity pressure under load conditions should not exceed 10 per cent of the static pressure. The air velocity should generally not exceed 2500 cu. ft. per minute. Air ducts are made of heavy steel but concrete ducts are commonly used. Duct sizes are determined in accordance with the general laws of frictional resistance.

CHAPTER XXVI

VENTILATORS AND NATURAL VENTILATION

OF the two methods of ventilating available, namely by mechanical means, and by the so-called natural forces, the later is often favored, because it is not dependent upon fans, blowers and motive power apparatus, any of which may get out of order; it requires no supervision, and it costs nothing for power to operate. It is dependent upon the operation of natural laws and is not subject to the requirements of control possible with mechanical ventilation.

Natural ventilation utilizes two separate agencies, (1) the buoyancy of the air caused by temperature difference between inside and outside of the building, and (2) the energy of the wind. The former is the same action that produces draft in a chimney. The two forces are entirely distinct and separate, and may either co-operate or oppose each other, depending upon the design of the ventilator.

A ventilator is an opening in the roof, properly protected against rain, snow and down draft; and surrounded by a hood or cowl intended to utilize the force of even the slightest breeze from any direction what-soever, in such a manner as to assist and increase air movement within an enclosure. Occasionally a damper is required to prevent over-ventilation in cold, stormy weather. In any event, openings near the floor of the building which is to be ventilated are necessary to allow the ventilators to act.

Ventilators may be classified in general as stationary and rotary, and each of these may be divided into siphoning and non-siphoning, the rotary ventilator being one which always presents the same face to the wind, and the siphoning ventilator being one which is so constructed as to use the force of the wind to siphon the air out of the ventilator, usually allowing some of the external air to pass through the head.

Engineers, architects and contractors who must make a selection should be guided by the following four general points, (1) quality of material, (2) design, (3) construction and (4) capacity (conditions should be stated otherwise a fair comparison of this item is impossible).

What is generally desired more specifically is, the greatest amount of reliable ventilation for a given cost of equipment. The following facts affect ventilation and ventilator capacity:

1. Temperature difference between inside and outside of building.
2. Height of ventilator above air inlet openings.
3. Wind velocity.
4. Design, shape and proportions of ventilator.

Material for this section furnished especially for THE GUIDE by Frank Kelley, Pittsburgh, Pa., C. T. Palmer, Akron, Ohio and Thornton Lewis, Philadelphia, Pa.

5. Air admission below the ventilator, (resistance to flow of air *into* building).
6. Resistance to air flow *through* the building.
7. Resistance to air flow in the ventilators themselves.
8. Location of the ventilator with respect to surrounding objects.

Of the factors mentioned, only items 4 and 7 depend upon the ventilator itself; the other items depend upon circumstances wholly outside of ventilator size and design.

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 handling or to be structurely weak when erected.
2. A storm band on stationary non-siphoning ventilators 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 oultet.
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. 87, consists of an outlet pipe with a conical hood above it. The addition of a storm band, as

shown in Figs. 88, 89 and 90, 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 utilizing the wind velocity to produce suction.

A further development of the later principle is the siphon ventilator, as illustrated in Fig. 91, in which siphons or ducts are introduced for the particular purpose of producing suction.

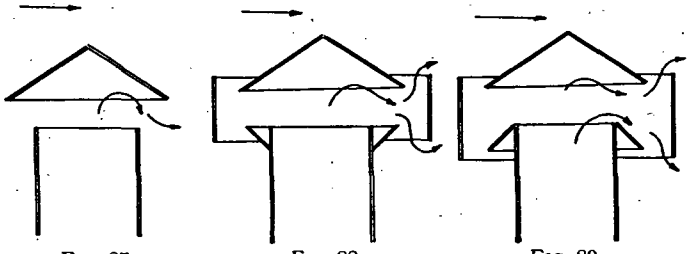


FIG. 87 FIG. 88 FIG. 89

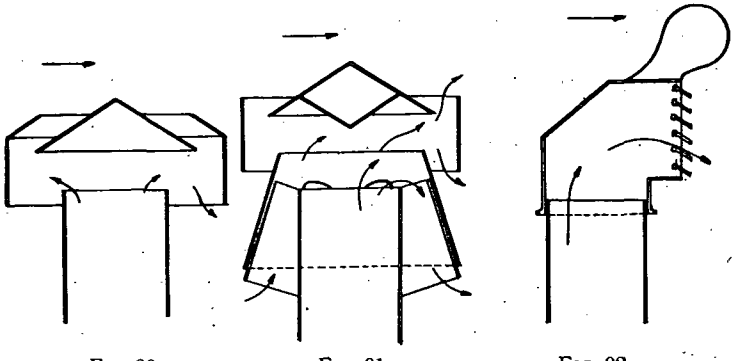


FIG. 90 FIG. 91 FIG. 92

VARIOUS STYLES OF ROOF VENTILATORS

In the swiveling or rotary ventilators, typified by Figs. 92 and 93, 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). For producing suction, it depends upon the viscous drag of the wind passing along the outside of the cowl.

In the induction or ejector type of ventilator, which is also of the swiveling or rotary type Fig. 94, the kinetic energy of the wind is used to a large extent by creating suction, due to the viscous drag both inside and outside the cowl. This device is effective for ventilation even with very low wind velocities. In some stationary ventilators of the siphon type, or of

the swiveling cowl type, low wind velocities have the effect of reducing the air discharge produced by the temperature difference, apparently because the laws of fluid flow are not the same at high and low velocities, which is an established fact.

All comparisons of capacity must be referred to a given dimension, namely the throat area, corresponding to the nominal size of the ventilator.

Resistance to flow of air is caused by; (1) restricted outlet openings, or (2) many turns or changes of the direction of the air 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 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. 95, is shown a rotary or air-turbine ventilator, which rotates continously under the action of the wind, the motion being produced by the difference of wind pressure on the convex and concave sides of the vanes. The air-exhausting action is due to centrifugal force. 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

The variety of factors affecting capacity makes it essential for the user of ventilators to exercise great care in respect to this item of capacity.

The draft in a ventilator head, due to the velocity of the wind, is primarily caused by the low pressure area or partial vacuum on the leeward side of the ventilator head. A draft in certain designs may also be caused by the siphoning action of the wind passing through the ventilator head, but any air which is allowed to enter the head to create a siphoning action must get out and in so doing will diminish the effective area of the head for exhausting air, and it is also very likely to reduce the effectiveness of the low pressure area.

Naturally the ventilator which makes the best use of the available forces for creating a draft and which at the same time provides the freest path for the flow of exhaust through the ventilators should be the best ventilator. It does not follow, however, that a ventilator of one class is better or poorer than one of any other class. It may be good or poor not because it belongs to a certain class, but depending upon whether the proper basic principles have been observed in its design.

The theoretical velocity of the gases due to temperature difference may be obtained from the following well-known formula:

$$V = \sqrt{2gH} = \sqrt{2gH\left(\frac{T^1}{T^0} - 1\right)}$$

in which

V = Velocity in feet per second
g = Gravity 32.2
H = Effective height of ventilator
T^1 = Temperature absolute of air in ventilator
T^0 = Temperature absolute of air outside.

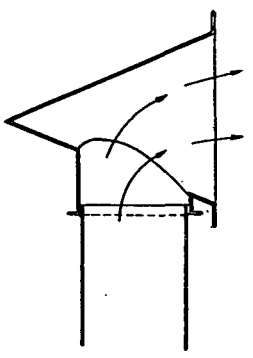


FIG. 93

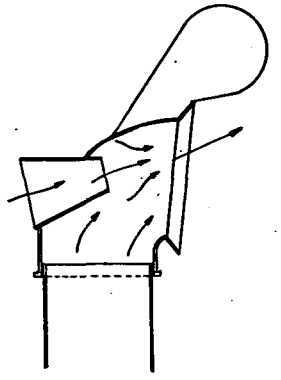


FIG. 94

ROTARY VENTILATORS

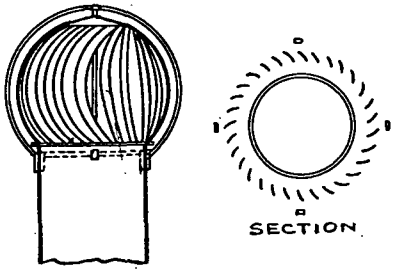


FIG. 95

AIR-TURBINE VENTILATOR

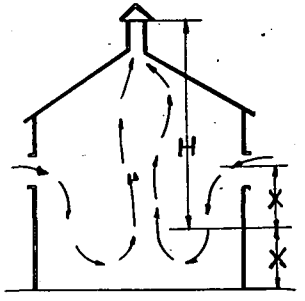


FIG. 96

DETERMINING THE EFFECTIVE HEIGHT

This gives the theoretical velocity which will be reduced in the practical case by the resistance in the pipe and the ventilator head. It is impossible to state an exact ratio between the velocity obtainable and the theoretical as every case will be different, but a reasonable assumption would be 50 per cent providing there is free admission of fresh air into the room or space ventilated.

Many exaggerated claims have been made in the marketing of ventilators and it was only recently that very careful tests were made by the U. S. Bureau of Standards (TRANS. A. S. H. V. E., Vol. 27, 1921, p. 67. See also TRANS., Vol. 28, 1922, p. 189 and Vol. 29, 1923, p. 39) and by other reliable investigators, with the result that ventilator capacities are now quite accurately known under specified test conditions.

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 floor, and with a wind velocity of V miles per hour, and average temperature t_i inside t_o outside.

The height H has been given as the height above the floor; strictly speaking, it is the height of the column of warm air in the building, which is approximately equal to the height above the location of the air inlet to the building. This location is usually near the floor. If, however, the inlet is much higher, as shown for instance in Fig. 96, the height H is indeterminate, but may, in general, be taken as halfway between the center of the air inlet and the floor.

Highest 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 floor, 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.

$$Q = 255. \times \left[\frac{36. \times \sqrt{35 \times (68 - 50)}}{6 + 6} + 20 \times 6 \right] = 50{,}000 \text{ cu. ft. per hr.,}$$

average capacity under these conditions.

VENTILATION REQUIREMENTS

The air supply per person and per hour, or the number of the renewals of air contents per hour is given in Chapter I, p. 23. (See also Chapter XV, p. 202.)

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;

$$\left[\frac{36 \times \sqrt{55 \times 10 \text{ deg.}}}{6 + 4 \text{ mi./hr.}} + 20 \times 4 \text{ mi./hr.} \right] = 165. \text{ cu. ft. of air per hr.}$$

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 $\sqrt{\frac{2420.}{.7854}} = 55.5$ inches. 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.

CONTROL OF VENTILATION

The ideal ventilator would be one which utilized to the very best advantage even the very lowest wind velocities; attained full capacity at a wind velocity of 4 or 5 miles per hour; and then automatically controlled the air flow so that the discharge remained constant at all higher wind velocities. Such an ideal ventilator does not exist.

The best types now on the market do, however, fulfill very well the

first two requirements; for the last one, hand regulation is depended upon. For this purpose either a butterfly damper is provided in the throat of the ventilator, or, in some of the rotary types, louvres are sometimes arranged at the discharge opening of the ventilator. The damper or louvres may be operated by chains from the floor of the building, or the butterfly damper electrically controlled by push button. The louvres with their operating device have the disadvantage of restricting the free area of discharge, even when open wide. In some designs, this results in a serious reduction of capacity. Ice can interfere with their operation. The dampers may be made to close automatically in case of fire, by use of a weight and fusible link arrangement. The dampers should be so located that ice cannot freeze them tight so that adjustment is impossible.

Regulation may also be accomplished, just as effectively, by restricting the flow of air into the building (closing the windows or doors), although this is quite inconvenient in many cases.

It is generally considered best practice to have the area to be ventilated between the intake and the exhaust. Also to have the intake 15 per cent greater in area than the exhaust.

The efficient ventilator uses every bit of wind energy striking it, to the fullest possible extent.

The ideal ventilator is then the one using all the forces at hand, to the greatest possible advantage. Such a ventilator must first be correctly designed to use all these forces—proportioned to use them efficiently—be strongly and practically built to last—needing no care or attention—as they are usually placed in inaccesible places.

APPLICATION OF VENTILATORS

The use of ventilators on factory and mill buildings is too well known to require comment. For pickling rooms, etc., where noxious fumes are produced, they are practically indispensable.

Ventilators for houses are becoming quite common, especially for the ventilation of bathrooms, which has been much neglected in the past. A frequent use for ventilators is on the top of chimneys, to prevent down drafts and to increase the updraft by means of wind action.

For use on houses, several requirements must be kept in mind. Good appearance and noiseless operation are very important. The motion of the ventilator, if of the revolving type, must not shake the building or cause knocks or thumps; and the construction must be such that in the winter the movable part does not freeze to the fixed portion of the ventilator and thus stop the rotation.

On account of the increasing danger of carbon monoxide poisoning, it is becoming regular practice to equip garages with ventilators to carry off the waste gases coming from motor exhausts.

Another application of ventilators is found in connection with power ventilating systems on the outlet or discharge opening.

A very important application for ventilators is on schools, where recirculation of air is used. The duty required, necessitates careful selection. Down draft must positively be eliminated.

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CATALOG DATA SECTION

(Pages 303–556)

with

INDEX TO TECHNICAL DATA SECTION

(Pages 557–562)

also an

INDEX TO MODERN EQUIPMENT

(Pages 563–576)

and

INDEX TO ADVERTISERS

(Pages 577–580)

Carrier Engineering Corporation

Atmospheric Conditioning Corporation

Offices and Laboratories: 750 Frelinghuysen Ave.

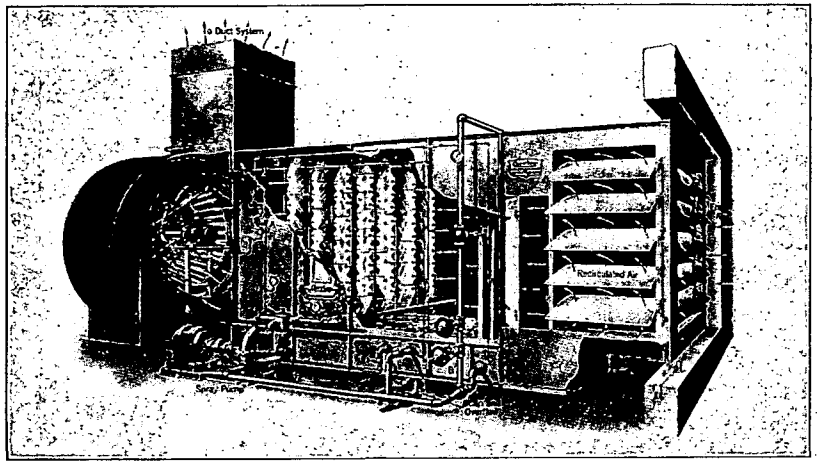
Newark, N. J.

BOSTON, 176 Federal Street — NEW YORK, 39 Cortlandt Street — CHICAGO, Burnham Building
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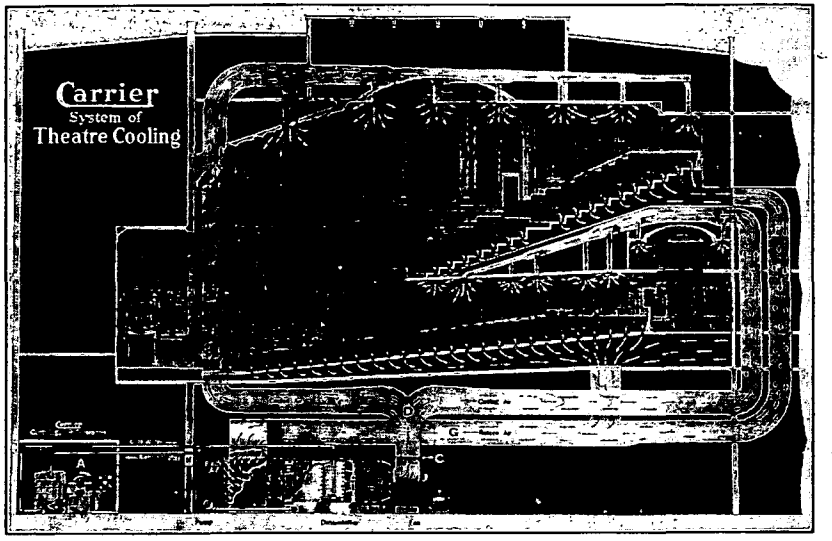
Engineers, Manufacturers, Contractors, specializing in the design and installation of automatically controlled Air Conditioning Equipment, Heating, Cooling, Ventilation, Humidification, Dehumidification, and the scientific application of Conditioned Air in Drying and Processing. Manufactured Weather to make "Every day a *good* day."

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Drying and Processing Equipment—The Carrier Ejector System of air circulation has been found almost universally and ideally adaptable to all drying and processing operations. By the ejector principle, all of the air within the drying room is set into uniform circulation over the material being treated. Drying rates and schedules are subjected to control by Carrier automatic instruments. The system is adaptable to periodic rooms or continuous tunnels. *Write for information on specific applications.*



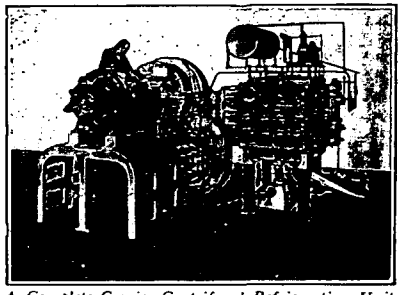
A Typical Carrier Humidifier or Dehumidifier showing the automatically controlled fresh and return air dampers, the spray chamber with pumping and water heating equipment and, on the left, the fan which delivers the air to the duct system



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.

Cooling and Air Conditioning in Public and Private Buildings—With a background of more than twenty years of 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. Numerous Carrier installations 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.*

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A Complete Carrier Centrifugal Refrigeration Unit. Capacity of this Unit 200 Tons

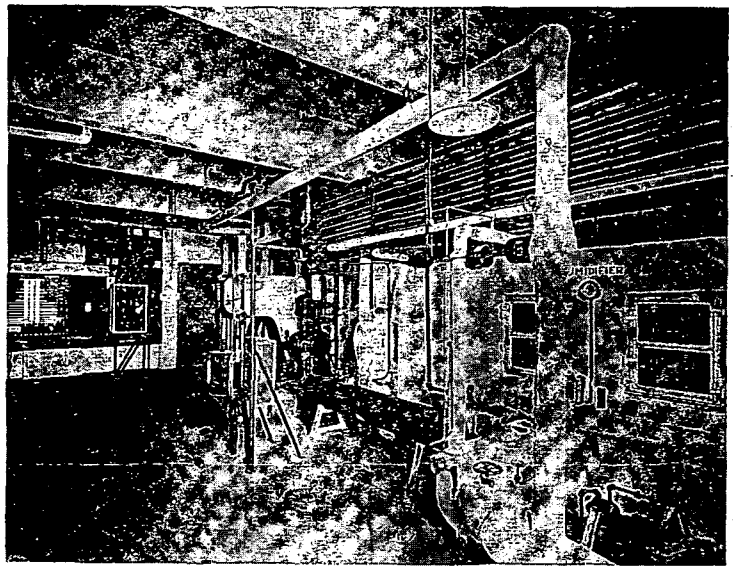
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Air Conditioning Systems are designed to overcome the handicaps imposed on industry by variations in weather, or adverse climatic conditions. They insure to the manufacturer that effect on materials and processes which can only be produced by ideal 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.

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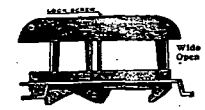
Knowles Mushroom Ventilator Co.

202-204 FRANKLIN STREET, NEW YORK

Knowles Air Diffusers for Auditoriums of Theatres, Churches, Schools

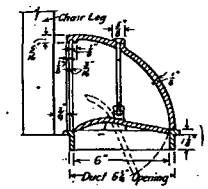
Nu-Notch Air Diffusers

Are finely adjusted by merely raising and lowering the cap in ten recessed notches, and locking. They cannot be tampered with and are made with lugs for either wood or concrete floors. No set screws. Three outer bearings make them rigid.



Size	C. F. M. at 300 Vel.	Area, Sq. Ft.	Weight, Lbs.
4" diam.	27	0.0873	2.75
5" "	42	0.1364	3.50
6" "	60	0.1964	4.25
7" "	81	0.2673	5.75
8"	105	0.3491	8.00
10" "	165	0.5454	11.75

Specification Data—For concrete floors furnish and place 6 in. cast iron mushroom air diffusers with recessed notches for permanent adjustment of mushroom caps at any desired opening; to have center screw locking feature, and L shaped lugs as manufactured by Knowles Mushroom Ventilator Co. Provide for each opening No. 20 galvanized iron sleeve extending through concrete floor; to be set when floor slab is laid. (See booklet page 6.)

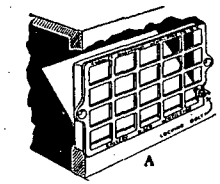


Standard Aisle Hood Air Deflectors

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.



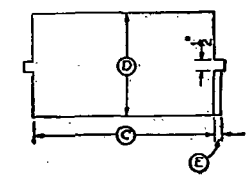
Riser Concrete Plan

Gallery Riser Ventilator

For the intake or exhaust of warm or cool air in the balconies of auditoriums adjustable to any opening and locked.

SIZE	A	B	C	D	E	Area Sq. Ft.	C.F.M. V 300	Lbs. Wt.
6	7 5/16	4 5/8	7 5/8	4 3/4	1/4	.196	60	2
8	9 5/8	6 3/8	10 1/4	6 3/4	1/4	.349	105	4
10	11 5/8	7 5/8	12 3/8	8 1/8	1/2	.545	165	6 1/2
12	16 3/8	10 3/4	17	11 3/8	1/2	.785	235	9 1/2

Also 6 x 12 Standard Size

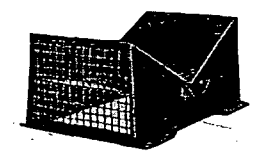


Camelback Air Diffusers

Give a two-way air delivery, at ends as shown and are particularly desirable in keeping duct work at a minimum. They are furnished with or without dampers. Nos. 1 and 3 have no dampers while Nos. 2 and 4 have two regulating dampers.

Nos. 1 and 3—Size 14" long, 7" wide, 6" high at ends.
Nos. 2 and 4—Size 14" long, 7" wide, 5" high at ends.

(See Booklet for Capacities)



All are of substantial construction being made of heavy cast iron. Other KNOWLES Products are Single Damper, Double Damper and Lever Lock Mushroom Ventilator, Disc-Loc Gallery Exhaust Vents.

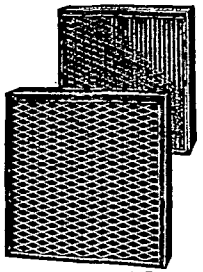
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Tangldust Air Filters, Cooling Towers for Theater Cooling Systems, Spray Nozzle Cooling Systems and Impact Air Washers

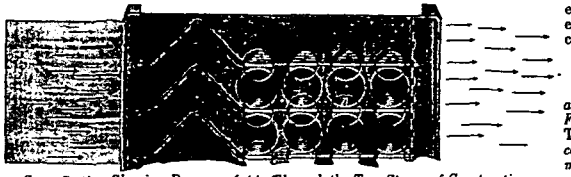
Tangldust "Two-stage" Air Filter



Front and Rear of Filter, Showing Wire Coils of Second Stage in Rear of Filter.

The Tangldust is a "two-stage" air filter, built in standard units, that removes 97 per cent of the precipitable dust and dirt. The "two-stage" feature is a refinement of ordinary filter design, and takes into consideration the fact that ordinary air contains both heavy dust and fibrous matter and also fine dust.

This type of construction provides for the depositing of the bulk of the coarser dirt on the first stage, consisting of baffle or eliminator plates vertically arranged across the front of the filter. The remaining dust which passes through the first stage is deposited on the wire coils of the second stage which are arranged in increasing density from front to rear of filter. This dust eventually dislodges and falls to the bottom of each coil, preventing the building up of a resistance to the air flow within the filter.



Cross Section Showing Passage of Air Through the Two Stages of Construction

THE WIDE RANGE OF APPLICATION.

GENERAL VENTILATION.—Schools, hospitals, hotels, museums, theaters, restaurants and public buildings.

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BACTERIA CONTROL.—Hospital operating rooms and contagious wards, bottling plants, etc.

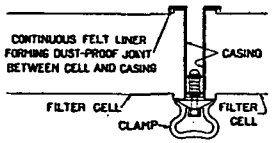
DUST RECOVERY.—For recovering valuable dust, such as gold and silver; also for control of injurious dust, such as lead, abrasives, chemicals, flour, starch, aluminum, etc.

DRYING OPERATIONS.—Butter, eggs, fruit, laundries, paint, milk, sugar and chemicals.

AIR COMPRESSORS.—Internal combustion engines and pneumatic tools.

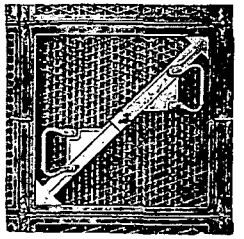
Important Features and Advantages of Tangldust Filters

DUSTPROOF CONSTRUCTION.—While the Tangldust filter cells or units are interchangeable, the supporting or enclosing frame is built to meet the specifications of each installation. This, together with our special dustproof joint — consisting of a continuous felt liner between the cell and casing—insures a dustproof installation even after many years of the most severe service.



Dustproof Joint

EASY TO CLEAN AND RECHARGE.—The method of cleaning the filter — consisting in placing the cell first in a cleaning and then in a charging tank, each operated by simply raising and lowering a counterbalanced bar—can be accomplished quickly and easily. The handling of the cells or units *is greatly simplified* by the use of a special removable handling bar, illustrated herewith.



Removable Handle for Easy Handling of Filter Cells

LESS FREQUENT RECHARGING.—This is the result of the use of the special removable oil pad, saturated with Tangelene oil, which is placed at the top of each filter cell. In operation, it continues to keep the filter surfaces constantly moistened with oil long after the ordinary filter has become inoperative. This naturally results in less frequent recharging being required.

VERY LOW UPKEEP COSTS.—The form of construction of the Tangldust filter, making cleaning much easier and recharging less frequent, makes it most economical in upkeep. The most inexperienced operator can easily take care of a good-sized installation.

Filter Specifications

Furnish and install as shown on plan, an air filter such as the Tangldust Air Filter manufactured by THE COOLING TOWER CO., INC., *New York, N. Y., capable of cleaning 800 cu. ft. of air per minute, velocity not to exceed 350 ft. per minute. Filter shall be constructed in two stages with a renewable oil pad at the top of each filter cell for greater efficiency, easier cleaning and to prevent the filter drying out between charging. Resistance of filter at 800 cu. ft. of air per minute per cell shall not be more than .2 in. water gage and not more than .3 in. when each cell has accumulated 1½ qts. of dust.*

SEND FOR BULLETIN 255-G

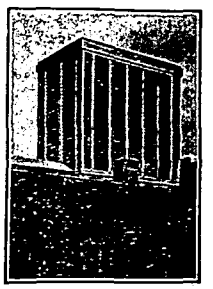
Cooling Towers for Theatre Cooling Systems

Cooling towers are designed to recool the circulating water in air refrigerating systems.

They are being very successfully applied to the cooling equipment of theatres, where they assure a plentiful supply of cool water being always available for the refrigeration system.

This eliminates frequent repairs and shutdowns of the system.

For further information send for catalogue.



Tower on Rivoli Theatre, New York City

DURO AIR FILTER COMPANY

HOME OFFICE—3151-3155 SHIELDS AVENUE

CHICAGO

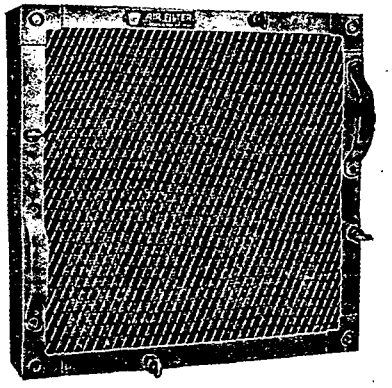
Represented in

NEW YORK CITY	CLEVELAND	AND
BOSTON	DETROIT	OTHER
MILWAUKEE	KANSAS CITY	PRINCIPAL
TORONTO	ST. LOUIS	CITIES

DURO COPPER MEDIA ALL METAL AIR FILTER

THE AIR FILTER EVERLASTING

With a copper filtration medium, a substance ideal for its purpose, DURO AIR FILTERS are suited to any application where a Clean Air Supply is important.



A Superior Product!

ALL PATENT RIGHTS RESERVED

Features of Importance:

1. Simple, Effective Cleaning accomplished by ordinary unskilled labor with minimum of difficulty!
2. By Rotative Cleaning a Constant effect in pressure characteristics is maintained!
3. Rough Stop of Coarse Dust!
4. Cavernous Region for Retention of Dust Load!
5. Final and Complete Elimination of Finest Particles!
6. Filtration Media Non-Friable!
7. Non-Corrosive!
8. Non-Magnetic!
9. Electrolytically Inert!
10. Lightweight, Durable, Sturdy Design and Construction Throughout!

Write for complete specifications and performance data

MIDWEST AIR FILTERS

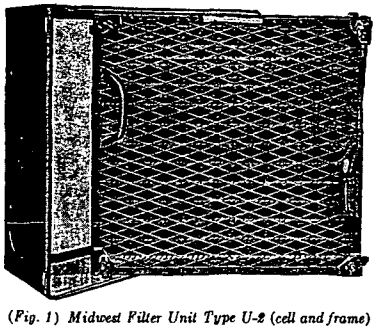
INCORPORATED

BRADFORD PENNSYLVANIA

Midwest Canada, Ltd. Montreal, Canada

Branches in Principal Cities

PRINCIPLE—Midwest Air Filters operate on the baffle-impingement principle. Each filter cell contains a series of specially perforated and shaped metal plates so designed that they form a graduate filter medium, which with larger openings and spaces for dust accumulations in the front has smaller openings with less spaces in the rear, thereby eliminating the coarser dust on the front sheets of the filter and the finer dust particles towards the rear of the filter cell. This design forces the air to change its direction many times in passing through the cell, and as the sheets are coated with a viscose, sticky fluid, "Viscosine", the dust particles are impinged against the sticky surface of the filter sheets at each change of direction of the air stream, where they are caught and held. At the extreme back of each cell an extra fine filter medium, consisting of a series of knitted copper mats of flat copper wire also coated with Viscosine, is arranged, thereby providing a very high efficiency.



(Fig. 1) Midwest Filter Unit Type U-2 (cell and frame)

SPECIAL FEATURES—Each filter unit consists of a frame and a cell, all of which are completely interchangeable.

Each frame is provided with a continuous flange in the rear, against which the filter cells are forced by thumb screws set in removable plate clips which fit into slots at the four corners of the frame. Thus air-tight joints are provided between all cells and frames.

Each frame is further provided with projecting turned-over lips, at one side and at the bottom. These lips grip and interlock with the adjoining side and top of adjacent frames. The frames themselves are bolted together at the rear. In this way, a double air seal is formed on all frames, and an absolutely air-tight installation assured.

INSTALLATION—An installation consists of the proper number of units assembled in an angle iron frame. Any limitations of space are easily and economically met.

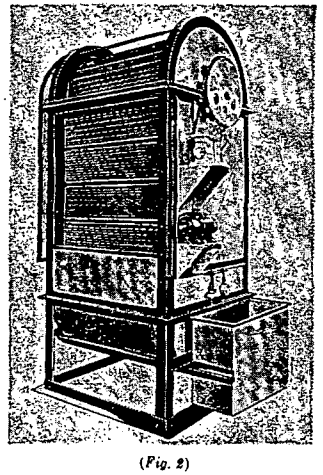
OPERATION AND MAINTENANCE—There being no moving parts, practically no operating supervision is required. Maintenance consists in periodical cleaning and recharging of cells in Viscosine.

Cleaning is systematically carried out by removing the cell next to the one last cleaned, and replacing at once by a clean, charged reserve cell. The dirty cell is washed in hot water and soda in a special tank provided with the installation. It is then drained and allowed to dry. When dry it is dipped in Viscosine and set aside to drain, when it serves as the next reserve cell.

The entire filter being constantly covered with Viscosine, does not corrode or rust. An installation is practically everlasting.

DATA AND SPECIFICATIONS

Size of unit (overall)—20 x 20 x 6½ in.
Size of Cell—19½ x 19½ x 4 in.
Net Weight of Cell—23 lb.
Weight of Unit—38 lb.
Capacity per Cell—Normal 800 cu. ft. per min.
Efficiency—The average efficiency, under normal operating conditions, is 97 to 99 per cent.
Resistance—Maintained at any desired value by routine cleaning and selecting proper velocity through filter.
Cleaning—Depends on dust conditions. In average installation, each cell is cleaned once every six to eight weeks. Time required—3 to 5 minutes per cell.
Viscosine Consumption—One gallon per unit per year.
Other types—We have a complete line of filters for various purposes and conditions. Figure 2 shows a filter of the self-cleaning type, and for further information please send your request to our Engineering and Research Department, who will gladly furnish data, sketches and recommendations without any cost or obligation to you.



(Fig. 2)

Reed Air Filter Co.

Incorporated

Factory and General Offices

202 Central Avenue : LOUISVILLE, KY.

NEW YORK OFFICE
50 CHURCH STREET

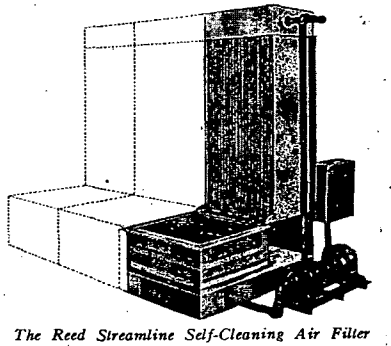
Reed Air filters all sizes

BRANCH OFFICES
IN PRINCIPAL CITIES.

The Reed System of Air Filtration provides a simple, economical and efficient method of supplying clean air for ventilation and industrial processes.

The Reed Streamline Air Filter represents the most recent development in the self-cleaning filter. It is automatic in operation, positive in performance, has no moving parts and requires no personal attention in its performance.

All mechanical movement has been eliminated. The filtering media is stationary—nothing moves but the charging liquid. Once a day the filter is automatically flushed or flooded with Adhesine which cleans the filtering media and leaves it freshly charged.



The Reed Streamline Self-Cleaning Air Filter

The filtering media of the **Reed Streamline (Self-Cleaning) Filter** consists of staggered rows of streamline forms similar to the low-wind-resistance shapes developed in the air service. These shapes

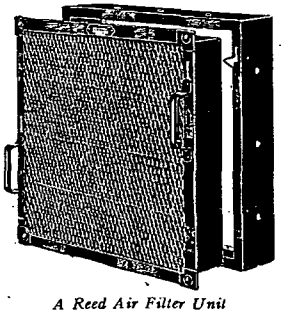


Low-Resistance Streamline Forms Used in Reed Self-Cleaning Filter

offer minimum resistance to air flow and clean the air by impingement on and scrubbing contact with Adhesine-coated surfaces.

The only auxiliary equipment is a small motor pump outfit. Adhering to the unit principle and building the **Reed Streamline Filter** in standard unit sizes has simplified laying out and installing filters of various capacities. Cleaning efficiency of the **Reed Streamline Filter** is 95 per cent—operating resistance, .25" of water.

The Reed Unit Air Filter operates on the principle of the human nostril. The split-wire filtering media, used in Reed Filters exclusively, divides the air into innumerable fine streams, bringing it into intimate contact with Adhesine-coated surfaces.



A Reed Air Filter Unit

Progressively packed media, varying in density through the depth of the filter, gives greater dust capacity, keeps resistance at a minimum and prolongs periods between cleanings.

Our Engineering Department will be glad to furnish complete data and drawings without cost or obligation.

Data and Specifications of Reed Air Filters

Size of Filter, over all	20x20x4 in.
Effective opening	18x18 in. (2¼ sq. ft.)
Capacity of each unit	800 cu. ft. per min.
Efficiency of Filter (Standard Type "B")	97%
Surface Area of Filter Media	1500 sq. ft.
Linear velocity of air through filter	365 ft. per min.
Resistance of clean filter to flow of air	½-in. water gauge

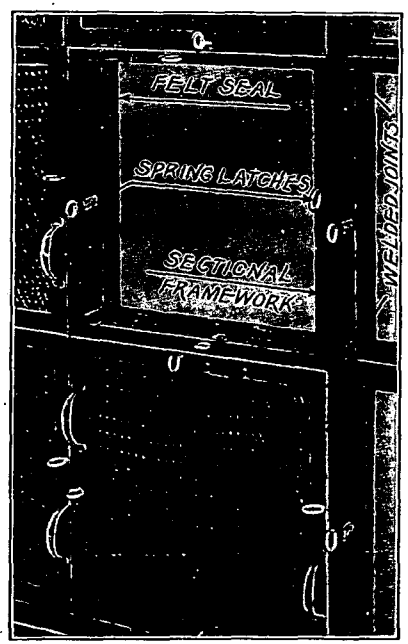
Frequency of cleaning depends upon amount of solids to be removed from air. For the average city air, cleaning periods may be estimated roughly as once in six to ten weeks. Time required for cleaning operation five to eight minutes.

Weight of filter cell	20 lb.
Weight of cleaning tank	45 lb.
Weight of filter frame	10 lb.
Weight of "Adhesine" per gal.	7.5 lb.

Spray Engineering Company

60 High Street
BOSTON, MASSACHUSETTS

SPRACO
AIR FILTERS



Spraco Air Filters constitute the most efficient device for removing from the ventilating air, dust, dirt, and other foreign matter. Some of the reasons why **Spraco Air Filters** are superior follow:

FIRST.—Filter media arranged from coarse to fine in the direction of air flow results in progressive filtration. Ample space provided for the accumulation of the maximum amount of dirt without obstructing the air flow.

SECOND.—Framework for holding cells is made up in sections of all welded construction, insuring maximum strength and perfect alignment. Sectional framework eliminates air leakage and reduces the cost of installation to a minimum.

THIRD.—Cells make two point contact with sectional framework, which is provided with a felt sealing strip. All air must pass through filter media.

FOURTH.—Quick acting spring latches, FOUR to each cell, hold the cells firmly against the two point seal.

FIFTH.—Washing tanks are equipped with steam water heater, drain, and water connections. Steam water heater insures maintaining washing solution hot, while the **Spraco** Rotary Washing tank is the quickest and most effective means of cleaning the cells.

Send for Bulletin F-47.

Engineering Service

The Spray Engineering Company maintains a corps of engineers experienced in all phases of air conditioning, including the filtering, washing, cooling, humidifying, and dehumidifying of air for all classes of work. These engineers are available for consultation regarding the best solution of such problems.

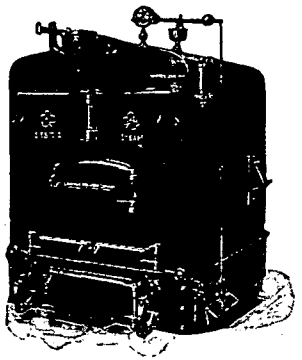
Specifications

Space occupied by Cell	20″ x 20″ x 4″.
Net weight of Cell	30 lbs.
Net weight of Sectional Framework	15 lbs. per cell.
Standard air capacity of Cell	800 C. F. M.
Average Resistance	¼″ w. g. when clean ⅓″ w. g. with 1 lb. dirt per cell.
Cleaning efficiency	Under normal conditions will remove 97% of dust and dirt as determined by microscopic dust count.

AMERICAN RADIATOR COMPANY

Western Executive Office	General Sales Department	Eastern Executive Office
816 South Michigan Ave.	1807 Elmwood Avenue	40 West 40th Street
CHICAGO, ILLINOIS	BUFFALO, NEW YORK	NEW YORK CITY

Manufacturers of Ideal Boilers, American Radiators, and other Heating, Ventilating, and Refrigerating Products



36″ Series

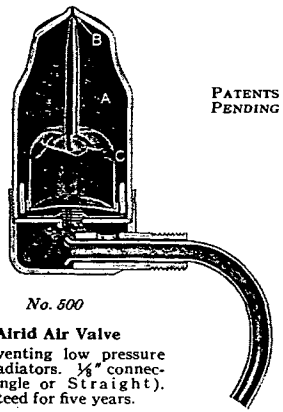
THE IDEAL SMOKELESS BOILER

The Ideal Smokeless Boiler has established itself by years of service as representing the highest standard of smokeless performance. It burns all grades of soft coal smokelessly without skilled attendance, is easily installed, requires no special setting, and has no parts to wear out or be replaced. It is especially well adapted for battery installation.

Complete data on Ideal Boilers and American Radiators are contained in the Ideal Fitter and special technical catalogs. Any branch of the company or the Advertising Department, 1807 Elmwood Avenue, Buffalo, New York, will be pleased to forward any of these catalogs on request.

Steam		Water		Grate Area Sq. Ft.	Fuel Capacity Lbs.	Total Length "L" Ins.	Steam Outlets No. and Size	Water Outlets No. and Size	Steam Inlets No. and Size	Water Inlets No. and Size	Chimney Size Ins.	Chimney Height Ft.
Number of Boiler	Rating Steam Sq. Ft.	Number of Boiler	Rating Water Sq. Ft.									
S-2308-S	1,050	W-2308-S	1,650	4.64	281	33	1-4	1-4	2-3	2-3	12 x 12	35
S-2309-S	1,200	W-2309-S	1,875	5.28	320	37	1-4	1-4	2-3	2-3	12 x 12	35
S-2310-S	1,350	W-2310-S	2,100	5.92	359	41	1-4	1-4	2-3	2-3	12 x 12	35
S-2311-S	1,500	W-2311-S	2,325	6.56	398	45	1-4	1-4	2-3	2-3	12 x 12	40
S-2312-S	1,650	W-2312-S	2,550	7.20	437	49	1-4	1-4	2-3	2-3	12 x 12	40
S-2907-S	2,400	W-2907-S	3,900	7.26	523	42	1-5	2-5	2-4	2-5	16 x 16	40
S-2908-S	2,800	W-2908-S	4,550	8.47	611	48	1-5	2-5	2-4	2-5	16 x 16	45
S-2909-S	3,200	W-2909-S	5,200	9.68	699	54	2-5	2-5	2-4	2-5	16 x 20	50
S-2910-S	3,600	W-2910-S	5,850	10.89	787	60	2-5	2-5	2-4	2-5	16 x 20	55
S-2911-S	4,000	W-2911-S	6,500	12.10	875	66	2-5	2-5	2-4	2-5	20 x 20	60
S-3608-S	4,450	W-3608-S	7,300	10.50	972	48	2-6	2-6	2-4	*	20 x 20	50
S-3609-S	5,100	W-3609-S	8,400	12.00	1,116	54	2-6	2-6	2-4	*	20 x 20	55
S-3610-S	5,750	W-3610-S	9,500	13.50	1,260	60	2-6	2-6	2-4	*	20 x 20	55
S-3611-S	6,400	W-3611-S	10,600	15.00	1,404	66	2-6	2-6	2-4	*	20 x 20	60
S-3612-S	7,050	W-3612-S	11,700	16.50	1,548	72	2-6	2-6	2-4	†	20 x 24	60
S-3613-S	7,700	W-3613-S	12,800	18.00	1,692	78	2-6	2-6	2-4	†	20 x 24	65
S-3614-S	8,350	W-3614-S	13,900	19.50	1,836	84	2-6	2-6	2-4	†	20 x 24	70
S-3615-S	9,000	W-3615-S	15,000	21.00	1,980	90	2-6	2-6	2-4	†	24 x 24	75
S-4807-S	9,000	W-4807-S	14,500	21.60	1,770	68½	3-6	3-6	4-4	4-6	24 x 24	70
S-4808-S	10,250	W-4808-S	16,500	25.20	2,065	79¼	3-6	3-6	4-4	4-6	24 x 24	75
S-4809-S	11,500	W-4809-S	18,500	25.20	2,065	90	3-6	3-6	4-4	4-6	24 x 28	80
S-4810-S	12,750	W-4810-S	20,500	28.80	2,360	100¾	3-6	3-6	4-4	4-6	24 x 28	85
S-4811-S	14,000	W-4811-S	22,500	28.80	2,360	111½	4-6	4-6	4-4	4-6	28 x 28	95
S-4812-S	15,250	W-4812-S	24,500	28.80	2,360	122¼	4-6	4-6	4-4	4-6	28 x 28	100
S-4813-S	16,500	W-4813-S	26,500	32.40	2,655	133	4-6	4-6	4-4	4-6	28 x 32	105
S-4814-S	17,750	W-4814-S	28,500	32.40	2,655	143¾	4-6	4-6	4-4	4-6	28 x 32	110
S-7909-S	14,000	W-7909-S	22,000	29.52	1,071	60	2-10	2-10	1-4	2-10	24 x 24	80
S-7910-S	15,500	W-7910-S	24,500	32.80	1,194	66	2-10	2-10	1-4	2-10	24 x 24	85
S-7911-S	17,000	W-7911-S	27,000	36.08	1,305	72	2-10	2-10	1-4	2-10	24 x 28	90
S-7912-S	18,500	W-7912-S	29,500	39.36	1,428	78	2-10	2-10	1-4	2-10	24 x 28	95
S-7913-S	20,000	W-7913-S	32,000	42.64	1,551	84	2-10	2-10	1-4	2-10	24 x 28	100
S-7914-S	21,500	W-7914-S	34,500	45.92	1,674	90	2-10	2-10	1-4	2-10	28 x 28	105
S-7915-S	23,000	W-7915-S	37,000	41.00	1,495	96	2-10	2-10	1-4	2-10	28 x 28	110
S-7916-S	24,500	W-7916-S	39,500	44.28	1,495	102	2-10	2-10	1-4	2-10	30 x 30	115
S-7917-S	26,000	W-7917-S	42,000	44.28	1,618	108	2-10	2-10	1-4	2-10	30 x 30	120

*Two 3½-inch and two 4-inch.
†Four 3½-inch and two 4-inch Safety Valve sizes accord with A. S. M. E. Boiler Code.

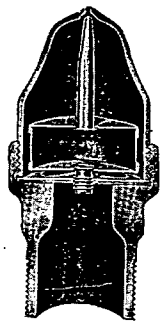


PATENTS PENDING

No. 500

Airid Air Valve

For venting low pressure steam radiators. ⅛" connection (Angle or Straight). Guaranteed for five years.

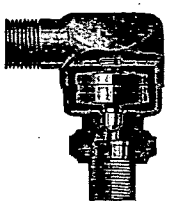


PATENT PENDING

No. 815

Ideal Quick Vent

All metal. Very sensitive. For venting mains, long runs of pipe, indirect stacks, drop risers, etc. No. 815—¾"; No. 820—⅜".

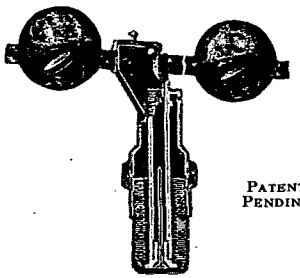


PATENT PENDING

No. 817

Vento Vent

For use on Vento Heaters and Blast Coils. Stack connection, ⅜"; Dup connection, ¼."

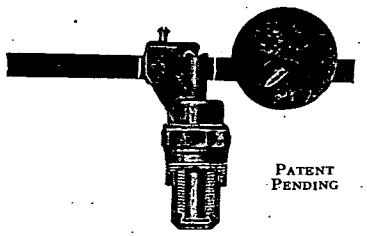


PATENTS PENDING

No. 800

Arco Water Regulator

For damper control on hot water heating boilers. Adjustable for temperature between 100° and 220°. All metal.
Length of Bulb 2⅞ inches. Connection, 2 inches.

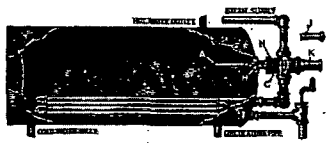


PATENT PENDING

No. 801

Arco Junior Water Regulator

For damper control on Hot Water Supply Boilers. Temperature range 130°–180°. Length of Bulb, 2 inches. Connection, 1½ inches.



PATENT PENDING

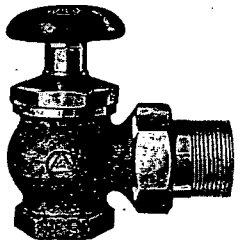
No. 825

Arco Tank Regulator

For temperature control of liquids heated by steam. (Also made in flexible tube type No. 826).
Range 140° to 180° F. For use on steam pressures up to 15 lbs.

Send for complete catalog of Ideal Heating Specialties

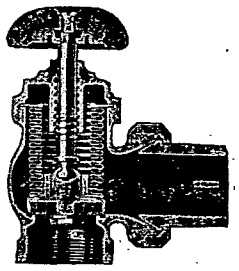
PACKLESS VALVES



No. 988

Arco Packless Valves—Quick Opening

Leakless feature consists of special moulded ring with metallic core held under compression by a spring. Requires no repacking. Opens or closes with one turn. Does not stick or bind. Furnished with either round or lever composition handle.
No. 988 Angle. No. 955 R. H. Corner. No. 960 L. H. Corner. No. 970 Globe. No. 968 Fractional Type with indicator and graduated dial.

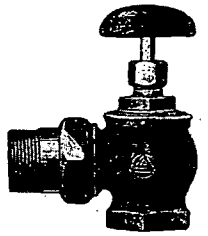


No. 850

Ideal Packless Valves—Bellows Type

Metallic bellows surrounds the stem and working parts, which prevents passage of steam, water or air around the stem opening. Equipped with round composition handle.
No. 850 Angle. No. 851 R. H. Corner. No. 852 L. H. Corner. No. 860 Globe.
Also furnished in Quick Opening type—one turn. Nos. 878, 879, 880, 870.

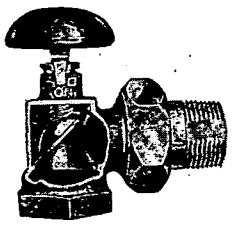
PACKED VALVES



No. 72

Detroit Steam Valves

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.



No. 101

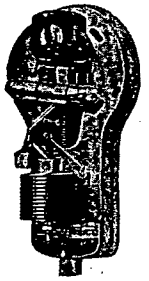
Detroit Hot Water Valve

The No. 101 Hot Water Valve will not stick or turn hard. The narrow edge of the plate presents a small area of contact so that corrosion is easily broken away. Concave plate gives true elbow shape when valve is open, reducing friction of water flow. Made in Angle pattern only.
Union Elbow, No. 132.

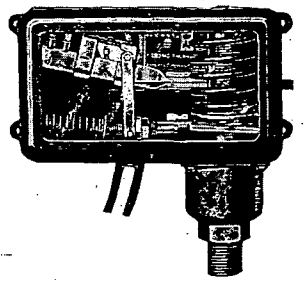
MERCOID CONTROLS

PATENTS PENDING

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. 845
Thermostat



No. 848 Type
For temperature, pressure, or vacuum

The Bigelow Company

Main Office and Works

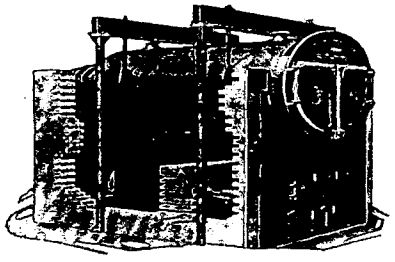
NEW HAVEN : CONNECTICUT

NEW YORK, N. Y.
149 BROADWAY

BOSTON, MASS.
141 MILK STREET

Manufacturers of

Bigelow-Hornsby Water Tube Boilers
Bigelow Horizontal Return Tubular Boilers
Bigelow Two-Pass Boilers
Bigelow Manning Boilers
Bigelow Upright Boilers



Bigelow H. R. T. Boiler

Investigation of the Bigelow H. R. T. boiler will convince you of its true value. Economical service has been the big feature of Bigelow products during a period of boiler building extending over 50 years. With a shop containing the most modern approved equipment for boiler construction a product is assured representing the highest quality in workmanship.

For Central Power Stations and large industrial plants the Bigelow Hornsby water tube boiler is unexcelled. High continuous economy, large overload capacity, large furnace volume and straight tubes are a few of the features contained in this type of boiler. The Hornsby is built in units of 375 H. P. to 3,000 H. P.

The Bigelow Two-Pass Boiler is the latest development of this company. After careful investigation of the existing types of steel heating boilers an effort was made to eliminate the objectionable features of many; the result being the Bigelow Two-Pass Boiler. This boiler will meet heating and power requirements especially where space limitations prevail: Elimination of staybolts and special brick shapes in furnace reduces maintenance to a minimum. Large furnace volume; long gas travel, uniform velocity of gas over heating surface and low exit temperature assures maximum efficiency.



Bigelow Two-Pass Boiler

Built in units from 25 H. P. to 150 H. P.

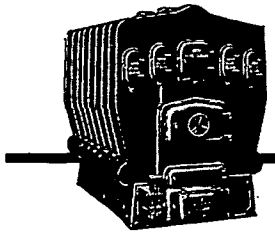
Burnham Boiler Corporation

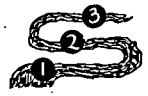
IRVINGTON, N. Y.

FACTORIES: IRVINGTON, N. Y. ELIZABETH, N. J. LANCASTER, PA.

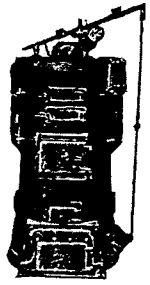
Offices: Boston, Mass., Chicago, Ill., Baltimore, Md., Philadelphia, Pa., New York City, N.Y., San Francisco, Calif.

Makers of Low Pressure and High Pressure Cast Iron Boilers

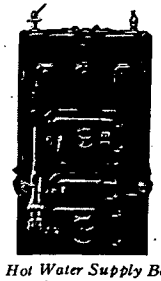




There are twenty members of the Burnham Family, in round and square boilers, each adapted to its particular place and purpose.



Round Sectional Steam Boiler Made for either water or steam heating. Has separate corrugated crown sheet section, and extra long fire travel.



The Hot Water Supply Boiler It has a wonderful reputation for the economical heating of water supply tanks. Sold equipped with following special features: Automatic Hot Water Damper Regulator; Hot Water Relief Valve set at 80 lbs., two 2 inch Brass Plugs on front section for clean-out purposes.

The One, Two, Three Of Oil Burning Economy

AS you know there is a wide variance of comparative costs in oil burning.

At best, it seems seldom to result in much better than an even break for residence heating.

This is largely due to most boilers having too short a fire travel.

This means that the necessary air pressure under which oil burning must be conducted, carries the hot gases too quickly to the chimney, causing an excess of heat losses.

Burnham boilers having a long fire travel, not only baffle down the speed of the gases; but also muffle the noise.

The Burnham Square Sectionals, with their three times back and forth fire travel, give high efficiency with oil fuels.

Continental Heater Corporation

Dunkirk, N. Y.

MANUFACTURERS OF CAST IRON BOILERS AND RADIATORS



Contento

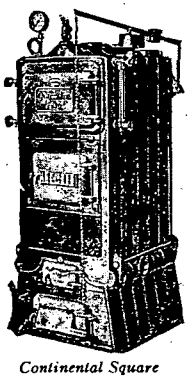
CONTENTO BOILERS

Boiler No.	Water Rating Sq. Ft.	Steam Rating Sq. Ft.	Overall Length Inches	Grate Area Sq. Ft.
4-A	400	240	20	0.94
5-A	535	320	23¾	1.22
6-A	670	400	27	1.55
7-A	825	500	30¾	1.92
8-A	990	600	34	2.25

CONTINENTAL SQUARE BOILERS

Boiler No.	Water Rating Sq. Ft.	Steam Rating Sq. Ft.	Overall Length Inches	Grate Area Sq. Ft.
417	750	450	33	1.44
517	1000	600	37	1.95
617	1250	750	41	2.45
717	1500	900	45	2.95
817	1750	1050	50	3.45

Four, five and six section boilers, 2–2½" flow and returns. Seven and eight sectional boilers, 3–2½" flow and returns. Water line 46 inches.



Continental Square

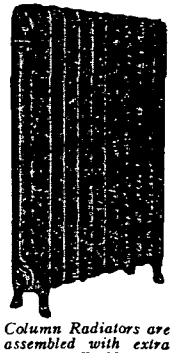
The Contento can be used either on the same floor with the radiators or in the basement.

The forward and back fire travel utilizes the gases instead of allowing them to be wasted up the chimney. The deep roomy firepot makes frequent attention unnecessary.

The Continental Square Boiler will hold fire for long intervals. The water tube design makes it a quick heater. The flues are easily cleaned and the boiler can therefore be run at highest efficiency at all times with soft as well as hard coal or coke.

CONTINENTAL RADIATORS

Each individual section is rigidly tested and inspected. After being assembled every radiator receives a second test. Continental Radiators are dependable.



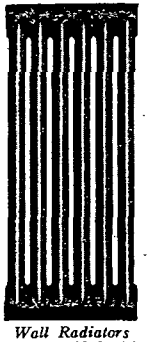
Column Radiators are assembled with extra heavy malleable nipples.

One Column	38"	32"	26"	23"	20"
Two Column	38"	32"	26"	23"	20"
Three Column	38"	32"	26"	22"	18"
Four Column	38"	32"	26"	22"	18"
Five Column	22"	18"	14"	...	...
Wall	7-B	9-B			

One, two and three column have 2½" centers.
Four and five column have 3" centers.

WALL RADIATION

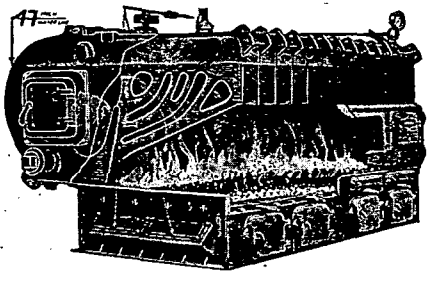
	Height	Width	C. T. to C. Tappings
7-B	22"	12"	19"
9-B	29"	12"	25⅝"



Wall Radiators are assembled with screw nipple.

Continental Low Water Line Boilers

Smokeless and Regular Types



Interior View

Superior Features

Extremely low water line, that of largest boiler being only 47 inches. Fired short way of grates, making firing easy. Water tubes in fire box come in direct contact with flames. Good circulation within boiler and large volume of water insures steady water line on fan systems. Made in regular and smokeless types. Will burn any kind of fuel including oil. **Every boiler set up and rigidly tested before shipment.**

CONTINENTAL LOW WATER LINE BOILER DATA

(Ratings have never been changed)

Smokeless Boiler Number	Regular Series Boiler Number	Steam Rating	Water Rating	Grate Area	Flow and Return 2 Each Inches	Front Length of Boiler Inches	Extreme Overall Depth Inches	Chimney Area Inches	Chimney Height Feet
20 Series Water Line 38 Inches—Height of Flow 43 Inches									
....	25	700	1,150	3.88	3	35	39½	8x12	40
....	26	900	1,500	4.85	3	42	39½	12x12	40
....	27	1,100	1,850	5.82	3	49	39½	12x12	40
....	28	1,300	2,200	6.80	3	56	39½	12x12	40
30 Series Water Line 43 Inches—Height of Flow 48 Inches									
530	35	1,200	2,000	5.83	4	35	54½	12x12	40
630	36	1,600	2,650	7.29	4	42	54½	12x12	40
730	37	2,000	3,300	8.75	4	49	54½	12x12	40
830	38	2,400	4,000	10.21	4	56	54½	12x12	40
930	39	2,800	4,650	11.67	4	63	54½	12x16	40
1030	310	3,200	5,300	13.13	4	70	54½	12x16	45
1130	311	3,600	6,000	14.59	4	77	54½	12x16	45
1230	312	4,000	6,650	16.05	4	84	54½	16x16	45
40 Series Water Line 47 Inches—Height of Flow 54 Inches									
640	46	2,500	4,150	9.72	5	42	79	12x16	50
740	47	3,200	5,300	11.66	5	49	79	12x16	50
840	48	3,900	6,450	13.60	5	56	79	16x16	50
940	49	4,600	7,600	15.54	5	63	79	16x20	55
1040	410	5,300	8,750	17.48	5	70	79	16x20	55
1140	411	6,000	9,900	19.43	5	77	79	20x20	55
1240	412	6,700	11,100	21.35	*5	84	79	20x20	60
1340	413	7,400	12,250	23.32	*5	91	79	24x24	65
1440	414	8,100	13,400	25.27	*5	98	79	24x24	65
1540	415	8,800	14,550	27.22	*5	105	79	24x28	65
1640	416	9,500	15,700	29.17	**5	112	79	28x28	70
1740	417	10,200	16,850	31.12	**5	119	79	28x28	70
1840	418	10,900	18,000	33.07	**5	126	79	28x32	70

*One additional 4-in. flow. **Two additional 4-in. flows. Double series boilers 2,600 to 22,300 sq. ft.

Fitzgibbons Boiler Co., Inc.

ESTABLISHED 1886

GENERAL OFFICES: 570 Seventh Avenue, NEW YORK CITY

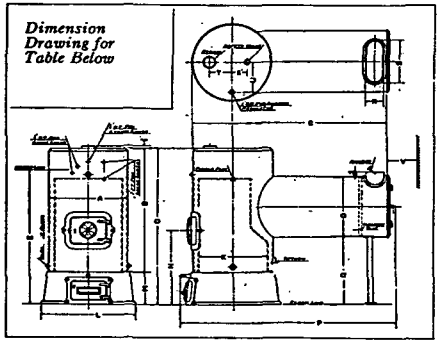
Products: Fitzgibbons-Ontario (small-sized) steel boilers for steam or hot water heating.

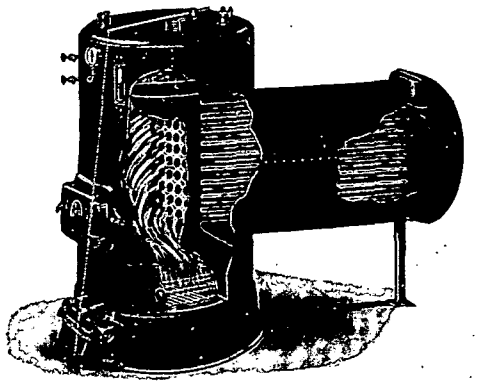
Fitzgibbons-Compac (intermediate sized) steel boilers for steam or hot water heating.

Fitzgibbons (large sized) steel boilers for heating. And for power, see page 322.

Reputation and Performance: For forty years Fitzgibbons Boilers have been known and recognized for their economy in coal consumption, quick steaming ability, and high evaporative power. Equally well-known have been their performance records for low cost operation and absence of maintenance cost.

Dimension Drawing for Table Below





Fitzgibbons-Ontario Steel Heating Boiler for small-sized installations, homes, churches, garages, etc.

Fitzgibbons-Ontario (Small-Sized) **Steel Boilers:** These boilers embody all the economical and efficient features of the larger sized Fitzgibbons boilers and are made in sizes ranging from 400 sq. ft. to 3200 sq. ft., steam rating or from 700 sq. ft. to 5100 sq. ft. water rating. The smallest size is 4 ft. 7 in. high, 5 ft. long and 2 ft. 2 in. wide, and is particularly suited for use in small residences where space is limited.

They are built entirely of rust-resisting copper-steel, assuring durability and a life-time of service.

FITZGIBBONS-ONTARIO STEEL BOILERS—Ratings and Specifications

Number of Boiler	H-8	H-12	H-16	H-20	H-24	H-28	H-32	H-36	H-44	H-50	H-58	H-64
Steam Rating	400	600	800	1000	1200	1400	1600	1800	2200	2500	2900	3200
Hot Water Rating	700	1000	1300	1600	1900	2200	2600	2900	3500	4000	4600	5100
A–Diam. Vert. Shell	26″	29″	29″	29″	33″	33″	36″	36″	40″	40″	43″	43″
B–Height Bare Boiler	3′–8½″	4′–1″	4′–1″	4′–1″	4′–1″	4′–1″	4′–4″	4′–4″	4′–8″	4′–8″	5′–0″	5′–0″
C–Length Bare Boiler	4′–2″	5′–0″	6′–0″	7′–0″	6′–5″	7′–5″	6′–9″	7′–9″	7′–7″	8′–7″	8′–4″	9′–4″
D–Diam. Hor. Shell	18″	21″	21″	21″	23″	23″	27″	27″	31″	31″	33″	33″
E–Floor to Water Line	3′–9″	4′–4″	4′–4″	4′–4″	4′–4″	4′–4″	4′–7″	4′–7″	4′–11″	4′–11″	5′–2″	5′–2″
K–Diameter Fire Box	21″	24″	24″	24″	28″	28″	31″	31″	34″	34″	37″	37″
L–Diam. Cast Iron Base	30″	33½″	33½″	33½″	37½″	37½″	40½″	40½″	42¾″	42¾″	45¾″	45¾″
M–Height Cast Iron Base	10½″	13″	13″	13″	13″	13″	13″	13″	13″	13″	13″	13″
N–Floor to Center Fire Door	26½″	31″	31″	31″	31″	31″	31″	31″	31″	31″	31″	31″
O–Height	4′–7″	5′–2″	5′–2″	5′–2″	5′–2″	5′–2″	5′–5″	5′–5″	5′–9″	5′–9″	6′–1″	6′–1″
P–Length Overall	5′–0″	5′–10″	6′–10″	7′–10″	7′–3″	8′–3″	7′–7″	8′–7″	8′–5″	9′–5″	9′–2″	10′–2″
Q–Height Cast Iron Stand	25¼″	28¾″	28¾″	28¾″	27¾″	27¾″	28″	28″	28″	28″	28″	28″
R–Width Smoke Uptake	5½″	6½″	6½″	6½″	7½″	7½″	8½″	8½″	9½″	9½″	10″	10″
S–Length Smoke Uptake	12½″	15½″	15½″	15½″	17½″	17½″	20½″	20½″	22″	22″	25″	25″
T–Location Supply Outlet	8″	8½″	8½″	8½″	10½″	10½″	11¼″	11¼″	13″	13″	12½″	12½″
U–Location Damper Reg	10″	12″	12″	12″	13″	13″	15″	15″	15″	15″	17″	17″
V–Suggested Behind Boiler	18″	23″	33″	45″	32″	44″	31″	43″	35″	47″	40″	52″
Supply Outlet	3″	4″	4″	4″	4½″	4½″	5″	5″	5″	5″	6″	6″
Return	3″	4″	4″	4″	4½″	4½″	5″	5″	5″	5″	6″	6″
Safety Valve	¾″	1″	1″	1″	1¼″	1¼″	1½″	1½″	2″	2″	2″	2″
Diameter Smoke Pipe	8″	10″	10″	10″	12″	12″	14″	14″	16″	16″	18″	18″
Approx. Sq. Ft. Covering	36	46	52	58	60	66	72	80	86	94	102	110
Approx. Shipping Weight	1750	1950	2000	2050	2300	2350	2900	2950	3550	3800	4200	4500

Ratings are based on two pounds pressure for steam and 180 deg. fahr. for water and give actual number of square feet direct cast iron radiator surface or equivalent when sufficient radiation is installed to heat the building to 70 deg. fahr.

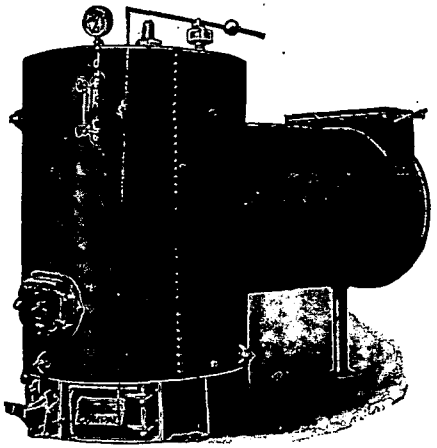
Fitzgibbons-Compac (Intermediate-Sized) **Steel Boilers:** This series is identical in general design with the large Fitzgibbons Boiler and is made in sizes from 3300 to 16,500 sq. ft. steam radiation. A most compact boiler specially adaptable to limited space conditions.

Construction: Fitzgibbons-Ontario and **Fitzgibbons-Compac** boilers are built completely of steel without a single cast-iron part holding water. Tested under pressure before shipment, and ready for immediate installation upon arrival at job. No assembling of parts at the building; no packed joints, unions, bolts, etc.

Fuel-Economy: The furnace with its gas diverting arch is so large, and the heating surfaces so ample, that the direct fire and major portion of flue surface is exposed to the hottest gases, utilizing all the heat available from the fuel. This results in a saving of upwards of 20 per cent in amount of fuel required in comparison with ordinary types of heating boilers.

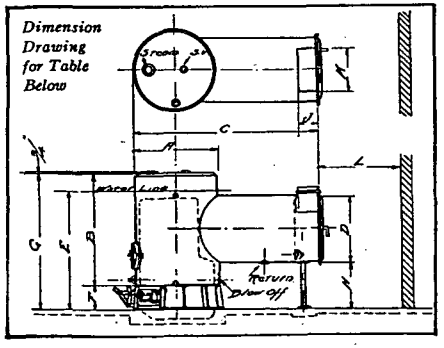
Burn Coal, Oil or Gas: The fuel-saving results whether egg, stove, chestnut, pea or buckwheat size of coal, or oil or gas is used as fuel. Unusually efficient when burning oil owing to large furnace and rapid water circulation.

Net Ratings: Ratings are net and indicate the amount of equivalent cast iron radiation that boilers will heat on the basis of 0.25 lbs. steam sq. ft. of equivalent cast iron radiation with the pressure at boiler two pounds, or 180 deg. fahr. temperature of water. Cast iron radiation equivalent is cast iron radiation plus heating loss of means, branches, risers, etc., plus hot water domestic-heating load plus heat loss of condensation not returned.



Fitzgibbons-Compac Steel Heating Boiler for moderate-sized plants

Dimension Drawing for Table Below



FITZGIBBONS-COMPAC STEEL BOILERS—Ratings and Specifications

No. of Boiler	Steam Rating Sq. Ft.	Diam. Vert. Shell A	Height Bare Boiler B	Length Bare Boiler C	Diam. Hor. Shell D	Water Line E	Over-all Height G	Height of Stand H	Smoke Uptake J x K	Space to Draw Tubes L	Approx. Sq. Ft. Covering	Approx. Weight in lbs.	Steam in.	Return in.
H-66	3300	4′–0″	5′–10″	8′–1″	3′–4″	6′–0″	7′–1″	2′–7″	13½″x26″	2′–9″	118	5500	6	4
H-76	3800	4′–0″	5′–10″	9′–1″	3′–4″	6′–0″	7′–1″	2′–7″	13½″x26″	3′–9″	128	5850	6	4
H-86	4300	4′–0″	5′–10″	10′–1″	3′–4″	6′–0″	7′–1″	2′–7″	13½″x26″	4′–9″	138	6200	6	4
H-88	4400	4′–4″	5′–11″	8′–7″	3′–6″	6′–0″	7′–2″	2′–5″	14″ x27″	2′–8″	132	6300	6	4
H-98	4900	4′–4″	5′–11″	9′–7″	3′–6″	6′–0″	7′–2″	2′–5″	14″ x27″	3′–8″	143	6650	6	4
H-108	5400	4′–4″	5′–11″	10′–7″	3′–6″	6′–0″	7′–2″	2′–5″	14″ x27″	4′–8″	154	7000	6	4
H-120	6000	4′–9″	6′–7″	9′–9″	4′–0″	6′–7″	7′–10″	2′–7″	14″ x37″	3′–8″	167	9000	7	5
H-132	6600	4′–9″	6′–7″	10′–9″	4′–0″	6′–7″	7′–10″	2′–7″	14″ x37″	4′–8″	180	9500	7	5
H-144	7200	4′–9″	6′–7″	11′–9″	4′–0″	6′–7″	7′–10″	2′–7″	14″ x37″	5′–8″	193	10,000	7	5
H-150	7500	5′–0″	6′–11″	9′–10″	4′–3″	6′–11″	8′–2″	2′–8″	14″ x44″	3′–8″	181	10,200	7	5
H-160	8000	5′–0″	6′–11″	10′–10″	4′–3″	6′–11″	8′–2″	2′–8″	14″ x44″	4′–8″	195	10,850	7	5
H-170	8500	5′–0″	6′–11″	11′–10″	4′–3″	6′–11″	8′–2″	2′–8″	14″ x44″	5′–8″	208	11,500	7	5
H-200	10,000	5′–4″	8′–6″	12′–0″	4′–6″	8′–3″	9′–9″	3′–3″	15″ x49″	6′–3″	260	13,000	8	6
H-220	11,000	5′–4″	8′–6″	13′–0″	4′–6″	8′–3″	9′–9″	3′–3″	15″ x49″	7′–3″	280	14,000	8	6
H-250	12,500	5′–10″	9′–0″	12′–3″	5′–0″	8′–9″	10′–3″	3′–3″	16″ x58″	6′–3″	295	15,000	8	6
H-270	13,500	5′–10″	9′–0″	12′–9″	5′–0″	8′–9″	10′–3″	3′–3″	16″ x58″	6′–9″	315	15,500	8	6
H-310	15,500	6′–2″	9′–2″	14′–0″	5′–2″	8′–11″	10′–5″	3′–3″	17″ x58″	7′–6″	335	17,000	8	6
H-330	16,500	6′–2″	9′–2″	14′–6″	5′–2″	8′–11″	10′–5″	3′–3″	17″ x58″	8′–0″	350	18,000	8	6

FITZGIBBONS Large Steel Boilers

The **Fitzgibbons Boiler** owes its high standing among architects, engineers and builders to (1) its capacity to carry its rating with ease (2) its coal-saving as compared with other types, and (3) its absence of maintenance cost.

Construction: The design embodies the strongest possible construction with a minimum of internal bracing. The combustion chamber is concentric with the vertical shell possessing similar strength. The interior of the boiler is readily visible and accessible in all parts for inspection and cleaning. Numerous handhole openings together with the manhole in the top head facilitate getting at all parts. Built completely of steel, eliminating all brick work.

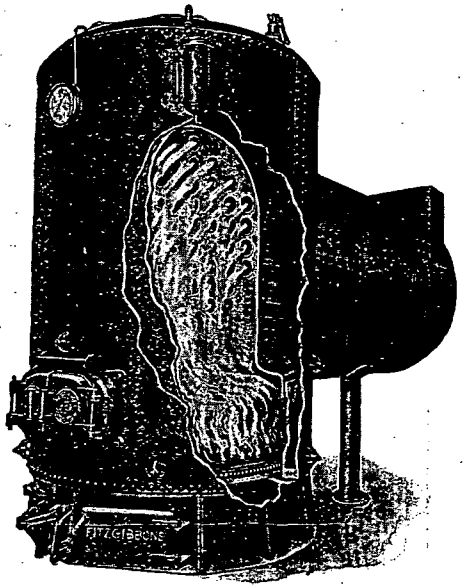
Steam Pressures: The Fitzgibbons Boiler for heating is built for 15 lbs. steam pressure to conform with the rigid requirements of the A. S. M. E. Boiler Code.

Combustion: Complete combustion of the fuel and its consumable gases in the combustion chamber with a minimum of excess air is a requisite of economical operation. The Fitzgibbons Boiler has a circular grate with no dead corners. The combustion chamber is over six feet in height, giving the ample furnace volume now recognized as essential for complete combustion. The lower crown-sheet of the furnace diverts the gases into a thorough mixture with the air admitted through the special opening over the fire-door. This mass of consumable gas is completely burned in the high combustion chamber before entering the tubes. Smokeless operation with semi-bituminous coal indicates the thoroughness of this combustion. Furnace temperatures have run close to 3000° F.

Circulation: The second requisite of economical operation is the rapid absorption of the heat by the water. This can be effected only by properly arranged heating surfaces over which a fast circulation is maintained. The horizontal shell with the tubes in the Fitzgibbons Boiler is completely submerged. The water-line is in the vertical cylinder immediately over the combustion chamber. As a result of this unique arrangement, the circulation is always towards the front of the boiler along a fixed path increasing its speed as it approaches the combustion chamber where the source of greatest heat exists. The perfection of this circulation is evidenced by (1) the quick-steaming ability of the boiler (2) less than one per cent moisture in the steam regardless of overload carried and (3) unusually low flue-gas temperatures.

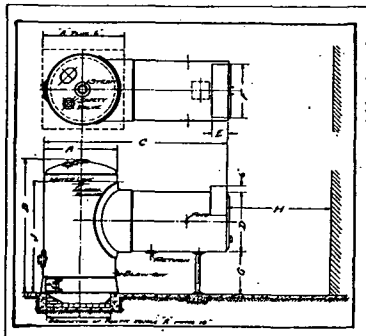
Economy: Forty years of operation under all sorts of conditions of fuel, supervision and load requirements have placed the fuel-saving characteristic of the boiler at over 20 per cent of the fuel ordinarily required by boilers of the rectangular-grate design. This economy results directly from the boiler's cylindrical construction, its complete combustion and its rapid water circulation.

Adaptability: The boiler requires little boiler-room space. To overcome unusual space limitations caused by irregular column or girder construction, the boiler can be specially built with the fire-door placed on any radius. Any fuel can be burned; semi-bituminous; anthracite buckwheat; oil; gas; wood or sawdust. An ever-increasing yearly production of this single boiler attests to its correctness of design, its economy in operation and its all-around efficient service.



Fitzgibbons Heating Boiler Showing Furnace

FITZGIBBONS BOILERS—Ratings and Specifications



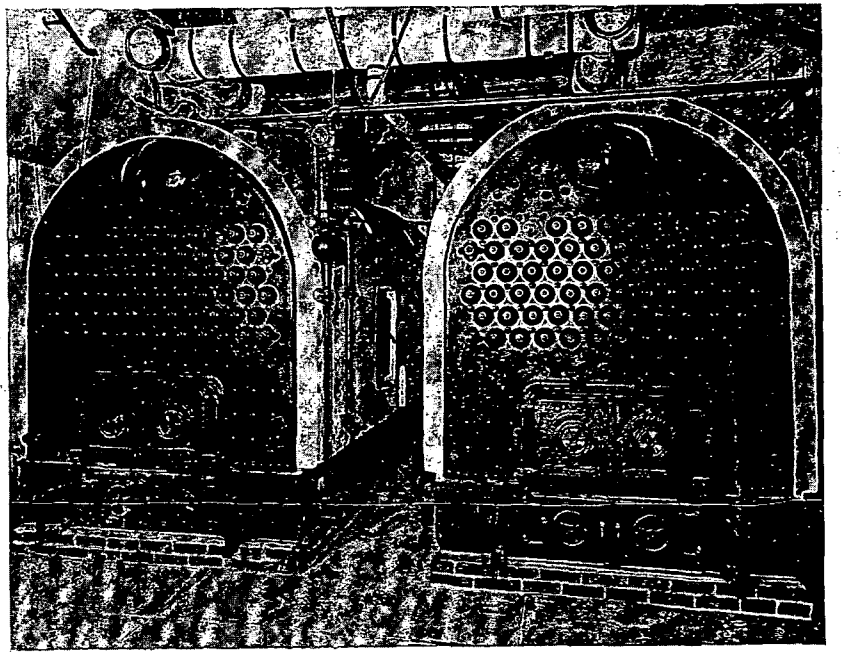
Number of Boiler	Steam Rating Sq. Ft.	Horse Power	Diam. Vert. Shell A	Height Over-all B	Length Bare Boiler C	Diam. Hor. Shell D	Smoke Uptake E x F	Height of Stand G	Space to Draw Tubes H	Water Line J
23	4200	40	4'-1"	8'-6"	9'-4"	3'-5"	12" x24"	3'-2"	4'-8"	7'-1"
24	5400	50	4'-5"	8'-9"	10'-6"	3'-8"	12" x31"	3'-2"	5'-7"	7'-4"
25	6400	60	4'-8"	9'-2"	10'-9"	3'-11"	13" x36"	3'-3"	5'-6"	7'-8"
26	7500	70	4'-10"	9'-5"	12'-2"	4'-1"	13" x42"	3'-4"	6'-10"	7'-11"
27	8500	80	5'-1"	9'-9"	12'-3"	4'-4"	13" x48"	3'-4"	6'-10"	8'-2"
29	11000	100	5'-5"	10'-1"	13'-7"	4'-7"	14½"x49"	3'-4"	7'-9"	8'-5"
30	13500	125	5'-11"	10'-8"	13'-11"	5'-1"	15½"x58"	3'-4"	7'-8"	8'-11"
31	16500	150	6'-3"	11'-0"	15'-1"	5'-3"	17" x58"	3'-4"	8'-6"	9'-1"
32	19000	175	6'-7"	11'-11"	15'-4"	5'-7"	18" x62½"	3'-9"	8'-4"	9'-10"
33	22000	200	6'-9"	12'-1"	16'-2"	5'-9"	19" x65"	3'-10"	8'-10"	10'-1"
34	25000	225	6'-11"	12'-2"	17'-5"	5'-9"	19" x65"	3'-10"	10'-0"	10'-1"
35	28000	250	7'-3"	12'-6"	18'-2"	6'-1"	20" x68"	3'-10"	10'-5"	10'-5"
36	32000	300	7'-8"	13'-11"	19'-2"	6'-6"	24" x73"	4'-4"	11'-0"	11'-4"
37	36000	350	8'-4"	14'-5"	19'-6"	7'-1"	24" x80"	4'-4"	11'-0"	11'-10"

*These sizes are also built for 100, 125 and 150 lbs. W. S. P. for power.

Harrisburg Star Boiler Corp.

15 Park Row, NEW YORK

Internally Fired, Self Contained Water Tube Boilers for Low Pressure Heating and Medium Pressure Power



Lower Water Lines and head room than fire-tube boilers.

Draft Areas which are sometimes restricted in fire tube boilers, are ample in Harrisburg Star Boilers allowing slower movement of gases giving more time for absorption of their heat.

Forced and Positive circulation through water tubes providing for effective transfer of heat from gases which cross tubes (3) times.

Both Inside and Outside surfaces of tubes can be cleaned. It is just as important to remove scale from water surfaces of tubes as it is to remove soot from fire surfaces.

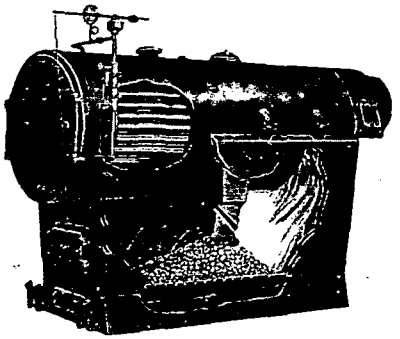
As a Safety Feature: The division of water into small masses prevents serious results in case of rupture.

General Boilers Company

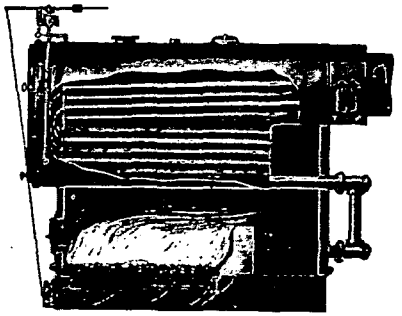
Manufacturers of

Pacific Steel Heating Boilers, Pacific Circulating Tanks

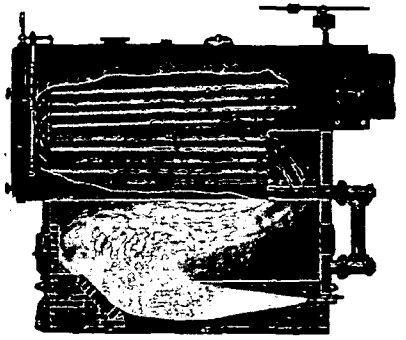
Waukegan, Illinois



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. A standard boiler policy is furnished with each steam boiler.

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—Steam	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
609	1900	64	14	13	50	6.77	152.0	4	2½	66½	42½	75	52	33½	12	33	27½	NOT LESS THAN SIX INCHES
610	2400	64	14	13	50	8.16	189.0	4	2½	78½	42½	75	64	33½	12	41	27½	
611	2900	68	16	15	55	9.47	234.0	5	3	81	46½	78	64	37½	12	41	31½	
612	3400	68	16	15	55	11.06	279.0	5	3	93	46½	78	76	37½	12	49	31½	
613	4000	68	18	17	60	11.85	318.0	5	3	94	49¼	79¼	76½	39½	12	49	33½	
614	4500	68	18	17	60	12.70	372.0	5	3	106	49¼	79¼	88½	39½	12	53	33½	
615	5000	75	18	17	60	12.07	392.0	6	3	96	58	89¼	76½	45½	12	41	39½	
616	5500	75	18	17	65	13.10	425.0	6	3	102	58	89¼	82½	45½	12	45	39½	
617	5800	75	18	17	65	15.15	457.6	6	3	108	58	89¼	88½	45½	12	53	39½	
618	6500	81	24	22	65	16.42	508.5	7	4	96	62½	96	76½	51½	12	49	45½	
619	7500	81	24	22	70	18.83	594.8	7	4	108	62½	96	88½	51½	12	57	45½	
620	8500	81	24	22	70	20.00	637.5	7	4	114	62½	96	94½	51½	12	61	45½	
621	9000	89	26	24	70	19.11	708.7	8	4	112	70½	106	88½	58½	12	49	52½	
622	10000	89	26	24	75	20.50	809.5	8	4	124	70½	106	100½	58½	12	53	52½	
623	12000	99	30	28	75	25.14	864.5	8	4	113	77½	117¾	88½	63	15	61	57	
624	14000	99	30	28	75	26.64	988.8	8	4	125	77½	117¾	100½	63	15	65	57	
625	15500	106	32	30	85	32.6	1183.8	8	5	129	86	125¾	100½	83½	15	57	77	
626	18000	106	32	30	85	34.7	1332.9	8	5	141	86	125¾	112½	83½	15	61	77	
627	20500	106	32	30	90	36.7	1482.0	10	6	153	86	125¾	124½	83½	15	65	77	
628	22000	119	36	33	100	39.1	1583.1	10	6	144	95½	140	113¾	96½	18	61	90½	
629	25000	119	36	33	100	41.4	1759.0	10	6	156½	95½	140	125¾	96½	18	65	90½	
630	28000	119	36	33	100	43.7	1934.9	10	6	168½	95½	140	137¾	96½	18	69	90½	

For Pacific Oil Fired Boilers use the above specification.

PACIFIC DIRECT DRAFT BOILERS

Catalogue Number	Net Rating—Steam	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
209	1600	64	14	13	45	6.77	152.0	4	2½	66½	42½	75	52	33½	12	33	27½	NOT LESS THAN SIX INCHES
210	1900	64	14	13	45	8.16	189.0	4	2½	78½	42½	75	64	33½	12	41	27½	
211	2400	68	16	15	50	9.47	234.0	5	3	81	46½	78	64	37½	12	41	31½	
212	2900	68	16	15	50	11.06	279.0	5	3	93	46½	78	76	37½	12	49	31½	
213	3300	68	18	17	55	11.85	318.0	5	3	94	49¼	79¼	76½	39½	12	49	33½	
214	3800	68	18	17	55	12.70	372.0	5	3	106	49¼	79¼	88½	39½	12	53	33½	
215	4100	75	18	17	55	12.07	392.0	6	3	96	58	89¼	76½	45½	12	41	39½	
216	4500	75	18	17	60	13.10	425.0	6	3	102	58	89¼	82½	45½	12	45	39½	
217	5000	75	18	17	60	15.15	457.6	6	3	108	58	89¼	88½	45½	12	53	39½	
218	5500	81	24	22	60	16.42	508.5	7	4	96	62½	96	76½	51½	12	49	45½	
219	6500	81	24	22	65	18.83	594.8	7	4	108	62½	96	88½	51½	12	57	45½	
220	7000	81	24	22	65	20.00	637.5	7	4	114	62½	96	94½	51½	12	61	45½	
221	7500	89	26	24	65	19.11	708.7	8	4	112	70½	106	88½	58½	12	49	52½	
222	8500	89	26	24	70	20.50	809.5	8	4	124	70½	106	100½	58½	12	53	52½	
223	10000	99	30	28	70	25.14	864.5	8	4	113	77½	117¾	88½	63	15	61	57	
224	11500	99	30	28	70	26.64	988.8	8	4	125	77½	117¾	100½	63	15	65	57	
225	13000	106	32	30	75	32.6	1183.8	8	5	129	86	125¾	100½	83½	15	57	77	
226	15000	106	32	30	75	34.7	1332.9	8	5	141	86	125¾	112½	83½	15	61	77	
227	17000	106	32	30	80	36.7	1482.0	10	6	153	86	125¾	124½	83½	15	65	77	
228	19000	119	36	33	90	39.1	1583.1	10	6	144	95½	140	113¾	96½	18	61	90½	
229	22000	119	36	33	90	41.4	1759.0	10	6	156½	95½	140	125¾	96½	18	65	90½	
230	25000	119	36	33	90	43.7	1934.9	10	6	168½	95½	140	137¾	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.

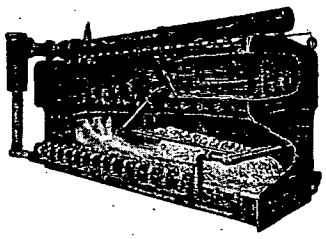
Complete catalog showing all types and sizes Pacific Boilers will be furnished on request.

Hart & Crouse Company

General Office: UTICA, N. Y.

Branch Offices in Principal Cities

Manufacturers of Royal Boilers and Furnaces



Royal Smokeless Boiler

ROYAL SMOKELESS BOILERS

Actual Steam Capacities—1670 to 16,600 Sq. Ft.

The Royal Smokeless Boiler is of the water tube down draft principle. This principle, originated by the Hart & Crouse Co. as applied to cast iron sectional boilers, has proved to be a most effective method of burning any grade of soft coal smokelessly independent of firing skill.

The large amount of heating surface in Royal Boilers is retained intact as originally designed. Consequently they produce results with efficiency and economy.

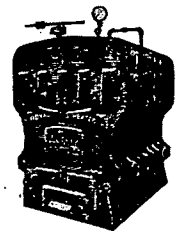
Boiler No.	Actual Capacity Steam Sq. Ft.	Actual Capacity Water Sq. Ft.	Current Rating Steam Sq. Ft.	Current Rating Water Sq. Ft.	Heating Surface Sq. Ft.	Grate Area Sq. Ft.	Length of Sections Inches	Length of Boiler Inches	Flow Tapping No. and Size	Return Tapping No. and Size	Smoke Pipe Inches
338	1,670	2,680	4,800	7,900	179	14.23	50¾	66	1–5″	2–3″	18
339	1,965	3,140	5,400	8,900	200	17.00	56¼	72	1–5″	2–3″	18
340	2,370	3,800	6,000	9,900	220	19.65	63	78	1–5″	2–3″	18
341	2,680	4,290	6,600	10,900	240	22.50	69	84	1–6″	2–4″	18
342	2,975	4,760	7,200	11,900	262	22.50	75¼	90	1–6″	2–4″	18
343	3,280	5,250	7,800	12,900	283	25.10	81¼	96	1–6″	2–4″	18
344	3,585	5,740	8,600	14,200	316	25.10	87½	102½	1–6″	2–4″	18
345	3,890	6,225	9,200	15,200	337	28.00	94	109	1–6″	2–4″	21
346	4,200	6,720	10,000	16,500	360	28.00	100	115	1–6″	2–4″	21
347	4,500	7,200	11,000	18,150	378	28.00	106¼	121	1–6″	2–4″	21
409	4,250	6,800	9,000	14,850	324	24.00	65⅜	93	1–8″	2–5″	21
410	4,750	7,600	10,000	16,500	359	27.50	72⅝	100	1–8″	2–5″	21
411	5,250	8,400	11,000	18,150	394	31.66	79⅞	108	1–8″	2–5″	21
412	5,750	9,200	12,000	19,800	427	31.66	86½	114½	1–8″	2–5″	21
413	6,250	10,000	13,000	21,450	461	31.66	93½	121½	1–8″	2–5″	21
414	6,750	10,800	14,000	23,100	496	35.50	101	129	1–8″	2–5″	24
415	7,250	11,600	15,000	24,750	531	35.50	108	136	1–8″	2–5″	24
416	7,775	12,450	16,000	26,400	565	35.50	115	143	1–8″	2–5″	24
548	7,400	11,850	14,000	23,100	511	37.50	83½	120½	1–8″	2–5″	24
549	8,470	13,550	15,800	26,070	573	45.00	93½	130½	1–8″	2–5″	24
550	9,480	15,170	17,600	29,040	642	45.00	104½	141½	1–10″	2–5″	24
551	10,200	16,330	19,400	32,010	710	45.00	114½	151½	1–10″	2–5″	24
552	11,250	18,000	21,000	34,650	773	52.50	124½	161½	1–10″	2–5″	24
553	12,200	19,550	23,200	38,280	841	52.50	135	172	1–10″	2–5″	24
554	13,000	20,800	25,000	41,250	909	52.50	145	182	1–10″	2–5″	24
555	13,900	22,250	26,800	44,220	978	52.50	155½	192½	1–10″	2–5″	24
556	14,800	23,700	28,800	47,520	1046	52.50	165½	202½	1–10″	2–5″	24
557	15,700	25,150	30,800	50,820	1114	52.50	176	213	1–10″	2–5″	24
558	16,600	26,550	32,600	53,790	1183	52.50	186½	223½	1–10″	2–5″	24
*54–8	7,400	11,850	14,000	23,100	511	37.50	83½	98½	3–6″	4–4″	24
54–9	8,470	13,550	15,800	26,070	573	45.00	93½	108½	4–6″	8–4″	24
54–10	9,480	15,170	17,600	29,040	642	45.00	104½	119½	4–6″	8–4″	24
54–11	10,200	16,330	19,400	32,010	710	45.00	114½	129½	5–6″	10–4″	24
54–12	11,250	18,000	21,000	34,650	773	52.50	124½	139½	5–6″	10–4″	24
54–13	12,200	19,550	23,200	38,280	841	52.50	135	150	5–6″	10–4″	24
54–14	13,000	20,800	25,000	41,250	909	52.50	145	160	6–6″	12–4″	24
54–15	13,900	22,250	26,800	44,220	978	52.50	155½	170½	6–6″	12–4″	24
54–16	14,800	23,700	28,800	47,520	1046	52.50	165½	180½	6–6″	12–4″	24
54–17	15,700	25,150	30,800	50,820	1114	52.50	176	191	6–6″	12–4″	24
54–18	16,600	26,550	32,600	53,790	1183	52.50	186½	201½	6–6″	12–4″	24

*Push Nipple Type.

Additional Data

Series	33″	40″	54″
Height of water line, Inches	63	68	68*
Height of flow outlet (Header type), Inches	90	99	108
Height of flow outlet (Push Nipple type), Inches			89
Overall width, Inches	68	78	97
Width at base, Inches	40	52	62½

*Height from top of foundation. Add 2″ for floor height.



Royal Sectional Boiler

ROYAL SECTIONAL BOILERS

Actual Steam Capacities—400 to 9,966 Sq. Ft.

Actual Water Capacities—667 to 16,000 Sq. Ft.

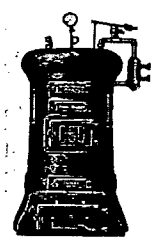
Additional Data

Series	22″	28″	36″	54″
Height of water line, Inches	46	54	63	68*
Height of flow outlet (Push Nipple type), Inches	56	65	75	89
Height of flow outlet (Header type), Inches	...	...	...	108
Width of boiler, Inches	36	44	56	80½
Width at base, Inches	32¼	38	45	62½
Smoke Pipe, Inches	10	12	15	24

*Height to top of foundation. Add 2″ for floor height.

Boiler No.	Actual Capacity Steam Sq. Ft.	Actual Capacity Water Sq. Ft.	Current Rating Steam Sq. Ft.	Current Rating Water Sq. Ft.	Max. Grate Area Sq. Ft.	Length of Sections Inches	Length of Boiler Inches	Steam Flows No. and Size	Steam Returns No. and Size	Water Flows No. and Size	Water Returns No. and Size
22–4	400	667	800	1,300	3.36	25	34	2–4″	4–3″	2–4″	4–4″
22–5	533	867	1,000	1,650	4.43	32	41	2–4″	4–3″	2–4″	4–4″
22–6	667	1,100	1,200	2,000	5.50	39	48	2–4″	4–3″	2–4″	4–4″
22–7	800	1,330	1,600	2,350	6.57	46	55	2–4″	4–3″	2–4″	4–4″
28–5	867	1,433	1,700	2,800	6.42	36	46¼	2–5″	4–4″	2–4″	4–4″
28–6	1,083	1,783	2,100	3,450	7.98	44	54¼	2–5″	4–4″	2–4″	4–4″
28–7	1,300	2,133	2,500	4,125	9.54	52	62¼	2–5″	4–4″	3–4″	6–4″
28–8	1,517	2,483	2,900	4,775	11.10	60	70¼	2–5″	4–4″	3–4″	6–4″
36–5	1,400	2,310	2,925	4,825	9.25	41	52	2–6″	4–4″	2–6″	4–4″
36–6	1,750	2,883	3,650	6,025	11.50	50	61	2–6″	4–4″	2–6″	4–4″
36–7	2,100	3,467	4,375	7,200	13.75	59	70	2–6″	4–4″	2–6″	4–4″
36–8	2,450	4,038	5,100	8,400	16.00	68	79	2–6″	4–4″	2–6″	4–4″
36–9	2,800	4,617	5,825	9,600	18.25	77	88	2–6″	4–4″	2–6″	4–4″
36–10	3,150	5,200	6,550	10,800	20.50	86	97	2–6″	4–4″	2–6″	4–4″
36–11	3,500	.....	7,275	.....	22.75	95	106	2–6″	4–4″	....	....
36–12	3,850	.....	8,000	.....	25.00	104	115	2–6″	4–4″	....	....
554–A	4,233	6,900	8,600	14,190	15.00	53	68	2–6″	4–4″	2–6″	4–4″
564	4,900	7,567	10,400	17,160	18.75	63	78	3–6″	6–4″	3–6″	6–4″
574	5,567	8,333	12,200	19,520	22.50	73	88	3–6″	6–4″	3–6″	6–4″
584	6,233	9,335	14,000	23,100	26.25	83½	98½	4–6″	8–4″	4–6″	8–4″
594	6,767	10,000	15,800	26,070	30.00	93½	108½	4–6″	8–4″	4–6″	8–4″
604	7,300	11,000	17,600	29,040	33.75	104½	119½	4–6″	8–4″	4–6″	8–4″
614	7,833	12,000	19,400	32,010	37.50	114½	129½	5–6″	10–4″	5–6″	10–4″
624	8,367	13,000	21,000	34,650	41.25	124½	139½	5–6″	10–4″	5–6″	10–4″
634	8,900	14,000	23,200	38,280	45.00	135	150	5–6″	10–4″	5–6″	10–4″
644	9,433	15,000	25,000	41,250	45.00	145	160	6–6″	12–4″	6–6″	12–4″
654	9,966	16,000	26,800	44,220	45.00	155½	170½	6–6″	12–4″	6–6″	12–4″
*854	4,233	6,900	8,600	14,190	15.00	53	90	1–8″	2–5″	1–8″	2–6″
864	4,900	7,567	10,400	17,160	18.75	63	100	1–8″	2–5″	1–8″	2–6″
874	5,567	8,333	12,200	19,520	22.50	73	110	1–8″	2–5″	1–8″	2–6″
884	6,233	9,335	14,000	23,100	26.25	83½	120½	1–8″	2–5″	1–8″	2–6″
894	6,767	10,000	15,800	26,070	30.00	93½	130½	1–8″	2–5″	1–10″	3–6″
703	7,300	11,000	17,600	29,040	33.75	104½	141½	1–10″	2–5″	1–10″	3–6″
713	7,833	12,000	19,400	32,010	37.50	114½	151½	1–10″	2–5″	1–10″	3–6″
723	8,367	13,000	21,000	34,650	41.25	124½	161½	1–10″	2–5″	1–10″	3–6″
733	8,900	14,000	23,200	38,280	45.00	135	172	1–10″	2–5″	1–10″	3–6″
743	9,433	15,000	25,000	41,250	45.00	145	182	1–10″	2–5″	1–10″	3–6″
753	9,966	16,000	26,800	44,220	45.00	155½	192½	1–10″	2–5″	1–10″	3–6″

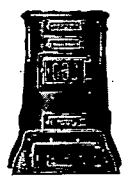
*Header Type.



Royal Round Steam Boiler

ROYAL ROUND BOILERS

Steam No.	Actual Capacity Sq. Ft.	Current Rating Sq. Ft.	Water No.	Actual Capacity Sq. Ft.	Current Rating Sq. Ft.
1035	178	425	1134	284	700
1045	244	625	1144	390	1030
1055	325	825	1154	520	1360
1065	415	1025	1164	664	1700
1075	525	1250	1174	840	2060
1037	200	475	1136	320	780
1047	280	700	1146	450	1150
1057	375	925	1156	600	1525
1067	480	1150	1166	768	1900
1077	625	1400	1176	1000	2300
1039	218	525	1138	339	870
1049	300	775	1148	480	1275
1059	425	1025	1158	680	1700
1069	575	1275	1168	920	2100
1079	700	1600	1178	1120	2640



Royal Round Water Boiler

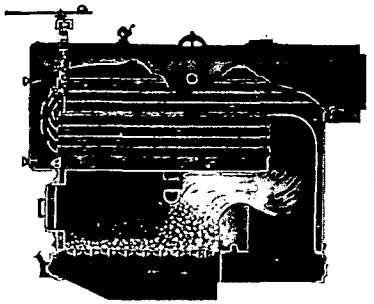
Heggie-Simplex Boiler Co.

Joliet, Illinois

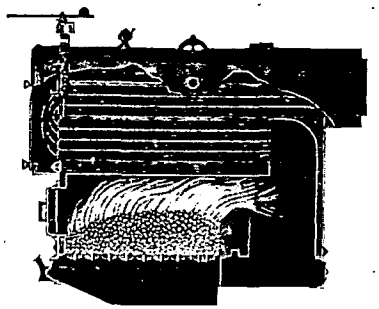
Heating Boiler Division of James G. Heggie & Sons, Manufacturers of Steel Boilers of all Kinds for over Thirty-four Years

Representatives in Principal Cities

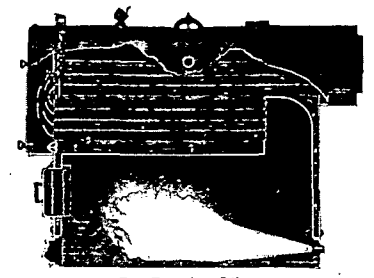
HEGGIE-SIMPLEX HEATING BOILERS



For Burning Soft Coal Smokelessly



For Soft or Hard Coal, Coke, Gas or Wood



For Burning Oil

During the thirty-five 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 their most 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 No. 26 to obtain more detailed information and specifications.

HEGGIE-SIMPLEX SMOKELESS STEAM HEATING BOILERS

Number of Boiler	*107	108	109	110	111	112	113	114	115	116	117	118	119	120
Capacity, sq. ft.	2000	2400	2800	3300	3700	4100	4500	5000	5500	6500	7000	7500	8500	10000
Heating Surface, sq. ft.	158	189	220	271	294	317	365	394	423	514	550	585	722	810
Grate Area, sq. ft.	10.6	10.6	11.8	12.2	13.7	15.2	14.7	16.5	18.3	18.6	20.7	22.7	22.9	22.9
Height Water Line, in.	62¼	62¼	62¼	69	69	69	72½	72½	72½	78½	78½	78½	81	81
Height of Boiler, in.	72	72	72	79	79	79	86	86	86	91	91	91	97	97
Width of Boiler, in.	34	34	34	40	40	40	47	47	47	52	52	52	57	57
Length of Boiler, in.	79	91	103	92	98	104	101	107	115	109	115	121	121	133
Width of Firebox, in.	29	29	29	34	34	34	41	41	41	46	46	46	51	51
Length of Firebox, in.	53	65	77	65	71	77	77	77	83	77	83	89	89	101
Diameter of Breeching, in.	20	20	20	22	22	22	24	24	24	26	26	26	28	28
Diameter of Stack, in.	18	18	18	20	20	20	22	22	22	24	24	24	26	26
Minimum Height of Stack, ft.	55	55	55	60	60	60	65	65	65	70	70	70	75	75
Diameter of Breeching—2 Boilers, in.	28	28	28	30	30	30	34	34	34	38	38	38	40	40
Diameter of Stack—2 Boilers, in.	26	26	26	28	28	28	32	32	32	34	34	34	36	36
Minimum Height of Stack—2 Boilers, ft.	65	65	65	70	70	70	75	75	75	80	80	80	85	85
Size of Steam Outlet, in.	6	6	6	6	6	6	8	8	8	8	8	8	8	8
Size of Return, in.	3	3	3	3	3	3	4	4	4	4	4	4	4	4
Number of Safety Valves	1	1	2	1	1	1	1	1	1	1	1	1	1	1
Size of Safety Valves, in.	2	2	2	2½	2½	2½	3	3	3	3	3	3	3½	3½
Boiler Covering Required, sq. ft.	78	89	101	104	116	116	125	133	141	144	152	160	176	193
Number of Boiler		121	122	123	124	125	126	127	128	129	130	131	132	133
Capacity, sq. ft.		11000	12000	13000	14500	15500	16500	18000	20000	22000	25000	28000	31000	34000
Heating Surface, sq. ft.		922	985	1047	1166	1238	1310	1403	1565	1911	2110	2309	2481	2695
Grate Area, sq. ft.		25.5	25.5	25.5	31.0	31.0	31.0	35.8	35.8	38.0	38.0	38.0	41.1	41.1
Height Water Line, in.		92¼	92¼	92¼	96	96	96	104¼	104¼	111¼	111¼	111¼	120	120
Height of Boiler, in.		108	108	108	116	116	116	126	126	132	132	132	141	141
Width of Boiler, in.		63	63	63	70	70	70	78	78	84	84	84	90	90
Length of Boiler, in.		123	129	135	129	135	141	141	153	153	165	177	177	189
Width of Firebox, in.		57	57	57	63	63	63	71	71	76	76	76	82	82
Length of Firebox, in.		89	95	101	94	100	106	100	112	112	124	136	136	148
Diameter of Breeching, in.		30	30	30	34	34	34	38	38	42	42	42	44	46
Diameter of Stack, in.		28	28	28	32	32	32	36	36	40	40	40	44	44
Minimum Height of Stack, ft.		75	75	75	80	80	80	90	90	100	100	100	110	110
Diameter of Breeching—2 Boilers, in.		44	44	44	50	50	50	54	54	56	56	56	64	64
Diameter of Stack—2 Boilers, in.		40	40	40	46	46	46	50	50	54	54	54	60	60
Minimum Height of Stack—2 Boilers, ft.		85	85	85	90	90	90	100	100	110	110	110	125	125
Size of Steam Outlet, in.		10	10	10	10	10	10	12	12	12	12	12	12	12
Size of Return, in.		5	5	5	5	5	5	6	6	6	6	6	6	6
Number of Safety Valves		2	2	2	2	2	2	2	2	2	2	2	3	3
Size of Safety Valves, in.		3	3	3	3	3	3	3	3½	4	4	4	3½	3½
Boiler Covering Required, sq. ft.		197	206	215	230	240	250	270	293	314	337	361	384	408

HEGGIE-SIMPLEX SMOKELESS HOT WATER HEATING BOILERS

Number of Boiler	*207	208	209	210	211	212	213	214	215	216	217	218	219	220
Capacity, sq. ft.	3300	3900	4500	5450	6100	6750	7400	8250	9100	10700†	11500	12300	13950	16400
Number of Supply Outlets	Heggie-Simplex Hot Water Boilers are furnished with the number of outlets specified on contractor's order													
Size of Supply Outlets, in.	3", 4", 5", 6", 7", 8", 10" or 12" are supplied, according to specifications on contractor's order													
Number of Return Openings	Heggie-Simplex Hot Water Boilers are furnished with the number of outlets specified on contractor's order													
Size of Return Openings, in.	3", 4", 5", 6", 7", 8", 10" or 12" are supplied, according to specifications on the contractor's order													

†This boiler contains no bridge wall; grates completely fill the base.

NOTE.—All other measurements on Nos. 207 to 220 are the same as on steam boilers Nos. 107 to 120.

HEGGIE-SIMPLEX DIRECT DRAFT STEAM HEATING BOILERS

Number of Boiler	*300	*301	*302	*303	*304	*305	*306	*307	308	309	310	311	312	313	314	315	316
Capacity...sq. ft.	600	750	900	1050	1200	1450	1700	2000	2400	2800	3300	3700	4100	4500	5000	5500	6500
Heating Surface...sq. ft.	50	64	75	86	94	116	141	158	189	220	271	294	317	365	394	423	514
Grate Area...sq. ft.	3.4	4.4	5.3	6.2	6.3	8.1	10.2	10.6	10.6	11.8	12.2	13.7	15.2	14.7	16.5	18.3	18.6
Height of Water Line...in.	48¾	55	55	55	58	58	58	62¼	62¼	62¼	69	69	69	72½	72¼	72½	78½
Height of Boiler...in.	54	61¼	61¼	61¼	66	66	66	72	72	72	79	79	79	86	86	86	91
Width of Boiler...in.	24	27	27	27	30	30	30	34	34	34	40	40	40	47	47	47	52
Length of Boiler...in.	48	52	58	64	58	70	82	79	91	103	92	98	104	101	107	113	109
Width of Firebox...in.	19	22	22	22	25	25	25	29	29	29	34	34	34	41	41	41	46
Length of Firebox...in.	26	29	35	41	35	47	59	53	65	77	65	71	77	71	77	83	77
Diameter of Breeching...in.	10	14	14	14	18	18	18	20	20	20	20	22	22	22	24	24	26
Diameter of Stack...in.	10	12	12	16	16	16	16	18	18	18	20	20	20	22	22	22	24
Minimum Height of Stack...ft.	30	40	40	40	50	50	50	55	55	55	60	60	60	65	65	65	70
Diameter of Breeching—2 Boilers...in.	16	20	20	20	26	26	26	28	28	28	30	30	30	34	34	34	38
Diameter of Stack—2 Boilers...in.	16	18	18	18	24	24	24	26	26	26	28	28	28	32	32	32	34
Minimum Height of Stack—2 Boilers...ft.	40	50	50	50	60	60	60	65	65	65	70	70	70	75	75	75	80
Size of Steam Outlet...in.	3	4	4	4	4	4	4	6	6	6	6	6	6	8	8	8	8
Size of Return...in.	3	2	2	1	2	2	2	3	3	3	3	3	3	4	4	4	4
Number of Safety Valves	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Size of Safety Valves...in.	1	1½	1½	1½	1½	1½	1½	1½	2	2	2½	2½	2½	2½	3	3	3
Boiler Covering Required...sq. ft.	33	41	46	51	51	62	73	76	89	101	104	110	116	125	133	141	144
Number of Boiler	317	318	319	320	321	322	323	324	325	326	327	328	329	330	331	332	333
Capacity...sq. ft.	7000	7500	8500	10000	11000	12000	13000	14500	15500	16500	18000	20000	22000	25000	28000	31000	34000
Heating Surface...sq. ft.	550	585	722	810	922	985	1047	1166	1238	1310	1403	1565	1911	2110	2309	2481	2695
Grate Area...sq. ft.	28.7	22.7	22.9	22.9	25.5	25.5	25.5	31.0	31.0	31.0	35.8	35.8	38.0	38.0	38.0	41.1	41.1
Height of Water Line...in.	78½	78½	81	81	92¼	92¼	92¼	96	96	96	104¾	104¾	111¼	111¼	111¼	120	120
Height of Boiler...in.	91	91	97	97	108	108	108	116	116	116	126	126	132	132	132	141	141
Width of Boiler...in.	52	52	57	57	63	63	63	70	70	70	78	78	84	84	84	90	90
Length of Boiler...in.	115	121	121	133	123	129	135	129	135	141	141	153	153	165	177	177	189
Width of Firebox...in.	46	46	51	51	57	57	57	63	63	63	71	71	76	76	76	82	82
Length of Firebox...in.	83	89	89	101	89	95	101	94	100	106	100	112	112	124	136	136	148
Diameter of Breeching...in.	26	26	28	28	30	30	30	34	34	34	38	38	42	42	42	44	46
Diameter of Stack...in.	24	24	26	26	28	28	28	32	32	32	36	36	40	40	40	44	44
Minimum Height of Stack...ft.	70	70	75	75	75	75	75	80	80	80	90	90	100	100	100	110	110
Diameter of Breeching—2 Boilers...in.	38	38	40	40	44	40	40	46	46	50	54	50	54	54	56	60	60
Diameter of Stack—2 Boilers...in.	34	34	36	36	40	40	40	46	46	50	54	50	54	54	54	60	60
Minimum Height of Stack—2 Boilers...ft.	80	80	85	85	85	85	85	90	90	100	100	110	110	110	110	125	125
Size of Steam Outlet...in.	8	8	8	8	10	10	10	10	10	10	12	12	12	12	12	12	12
Size of Return...in.	4	4	4	4	5	5	5	5	5	5	6	6	6	6	6	6	6
Number of Safety Valves	1	1	1	1	2	2	2	2	2	2	2	2	2	2	2	3	3
Size of Safety Valves...in.	3	3	3½	3½	3	3	3	3	3	3	3½	3½	4	4	4	3½	3½
Boiler Covering Required...sq. ft.	152	160	176	193	197	206	215	230	240	250	270	293	314	337	361	384	408

HEGGIE-SIMPLEX DIRECT DRAFT HOT WATER HEATING BOILERS

Number of Boiler...sq. ft.	*400 1000	*401 1250	*402 1500	*403 1750	*404 2000	*405 2400	*406 2800	*407 3300	408 3900	409 4500	410 5450	411 6100	412 6750	413 7400	414 8250	415 9100	416 10700	417 11500	418 12300	419 13950	420 16400
Number of Supply Outlets...1	Heggie-Simplex Hot Water Boilers are furnished with the number of outlets specified on the contractor's order																				
Size of Supply Outlets...in. 3	3", 4", 5", 6", 7", 8", 10" or 12" are supplied, according to specifications on the contractor's order																				
Number of Return Openings...1	Heggie-Simplex Hot Water Boilers are furnished with the number of openings specified on the contractor's order																				
Size of Return Openings...in. 3	3", 4", 5", 6", 7", 8", 10" or 12" are supplied, according to specifications on the contractor's order																				

*This boiler contains no bridge wall; grates completely fill the base.

NOTE.—All other measurements on Nos. 400 to 420 are the same as on the steam boilers Nos. 300 to 320.

INTERNATIONAL HEATER COMPANY

Makers of Heating Apparatus

Utica, N. Y.

NEW YORK, Fisk Bldg., Broadway and 57th St.
CHICAGO, 1933-35 Wentworth Ave.
CLEVELAND, 1441 Davenport Ave., N.E.
DETROIT, 1114 Dime Savings Bank Bldg.
PHILADELPHIA, 1613 Filbert St.
NASHAU, N. H., 110 Chestnut St.

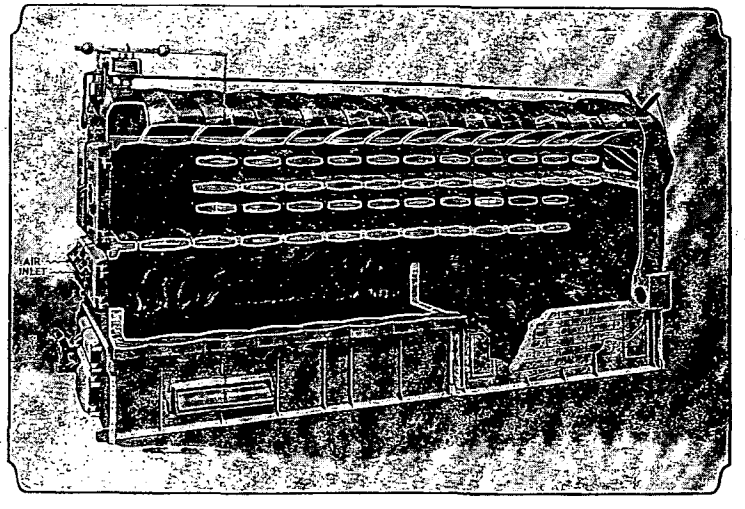
ECONOMY BOILERS

On the following pages we present condensed data on the INTERNATIONAL ROUND BOILERS, ECONOMY SECTIONAL BOILERS, both the Regular Pattern, and Mixing Arch and Wing Wall Type Smokeless Patterns.

INTERNATIONAL GUARANTEED RADIATION Loads make possible the immediate and accurate selection of the proper boiler size for any job. All guess work is eliminated. Proper allowance has already been made to cover piping mains and risers. These Guaranteed Radiation Loads have been determined from tests in our Research Department. The INTERNATIONAL HEATER COMPANY supports these Guaranteed Radiation Loads absolutely. The guarantee under which INTERNATIONAL Economy Steam and Water Boilers are rated reads:

> "We *guarantee* INTERNATIONAL ECONOMY steam and water boilers to maintain 2 pounds steam pressure or 180° temperature at the boiler, on the *guaranteed* amount of direct cast iron radiation shown for each size. Additional loads such as domestic hot water supply, direct-indirect and indirect radiators, blast coils, or rooms to be maintained below 70° temperature, must be reduced to and included in equivalent square feet of direct cast iron radiation.
>
> "This *guarantee* is based on fuel of at least 11,500 B.t.u. and a chimney providing sufficient draft to properly burn the fuel."

Both the Regular and the Smokeless types have the following distinctive features in common: A long fire travel and all heating surface *below* the water line; a *low steady* water line with water gauge tapped directly into the section; *dry steam guaranteed without a header and only one main outlet from boiler;* grate bar connections of sectional boilers are *outside* the ashpit; all heating surface easily *cleaned from front* of boiler through large flue doors.

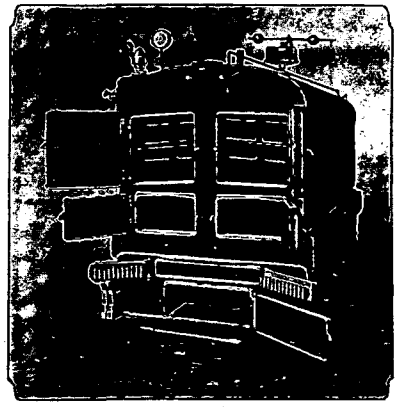


Cut-Away View of No. 140-S-47 Economy Smokeless Boiler

INTERNATIONAL HEATER COMPANY

SECTIONAL MEASUREMENTS
Smokeless Steam Sizes

Series	Height of Water Line, Inches	Diameter of Smoke Outlet, Inches	Height to Supply Outlet, Inches	Add to Height for Trimmings, Inches	Width of Boiler, Including Trimmings, Inches	Height from Floor to Center of Return Tappings, Inches	Height of Fire Box to Crown, Inches	Height, Grate to Middle of Feed Door, Inches	Size of Feed Door, Inches
22	47	12	57	11	39	19	22	16	9x17
28	50	14	62½	11	45	19½	24	18	9x17
34	54	16	68	11	54	20	26	18	11x21
47	59	24	73	12	63	21½	26	18	2-10x17



47 in. Series Economy Smokeless Boiler Showing Access for Cleaning

Ratings and Dimensions ECONOMY SMOKELESS BOILERS‡ (Steam Pattern)

Number **	Guaranteed Radiation Load Sq. Ft.	Commercial Rating Sq. Ft.	Grate Area Sq. Ft.	Additional Area Side Grate, Sq. Ft.	Coal Capacity Pounds	Minimum Chimney Dimensions		†Tappings	
						Size of Flue Inches	Height Feet	Supply	Return
60-S-22	837	2200	6.4	3.0	460	12 x 12	35	2-3½"	2-3½"
70-S-22	1008	2650	7.3	3.3	545	12 x 12	40	2-3½"	2-3½"
80-S-22	1183	3100	8.5	3.7	630	12 x 12	40	3-3½"	2-3½"
90-S-22	1354	3550	9.7	4.1	715	12 x 12	45	3-3½"	2-3½"
100-S-22	1525	4000	11.0	4.4	800	12 x 16	50	3-3½"	2-3½"
60-S-28	1079	2850	8.2	3.3	590	16 x 16	35	2-4"	2-4"
70-S-28	1306	3450	9.3	3.7	705	16 x 16	40	2-4"	2-4"
80-S-28	1533	4050	10.8	4.1	820	16 x 16	40	3-4"	2-4"
90-S-28	1770	4650	12.4	4.4	935	16 x 16	45	3-4"	2-4"
100-S-28	1998	5250	14.0	4.8	1050	16 x 16	50	3-4"	2-4"
70-S-34	1720	4500	11.3	4.0	985	16 x 16	45	3-5"	2-5"
80-S-34	2010	5250	13.2	4.1	1135	16 x 16	45	3-5"	2-5"
90-S-34	2300	6000	15.1	4.7	1285	16 x 16	50	3-5"	2-5"
100-S-34	2600	6750	17.0	5.1	1435	16 x 20	50	3-5"	2-5"
110-S-34	2900	7500	13.2	4.4	1135	20 x 20	55	3-5"	2-5"
120-S-34	3200	8250	15.1	4.7	1285	20 x 20	55	3-5"	2-5"
130-S-34	3510	9000	15.1	4.7	1285	20 x 20	60	3-5"	2-5"
140-S-34	3815	9750	17.0	5.1	1435	20 x 24	60	3-5"	2-5"
150-S-34	4150	10500	17.0	5.1	1435	20 x 24	60	3-5"	2-5"
61-S-47	3300	7950	16.32	4.70	1250	20 x 24	55	2-6"	2-6"
71-S-47	3890	9450	19.58	5.16	1500	20 x 24	55	2-6"	2-6"
81-S-47	4500	10950	22.85	5.60	1750	24 x 24	60	3-6"	2-6"
91-S-47	5100	12450	26.11	6.06	2000	24 x 24	60	3-6"	2-6"
100-S-47	5715	13950	19.5	5.1	1500	24 x 24	65	3-6"	2-6"
110-S-47	6385	15450	19.5	5.1	1500	24 x 24	70	3-6"	2-6"
120-S-47	7075	16950	19.5	5.1	1500	24 x 28	70	4-6"	2-6"
130-S-47	7800	18450	22.8	5.6	1750	24 x 28	75	4-6"	2-6"
140-S-47	8550	19950	22.8	5.6	1750	24 x 28	75	4-6"	2-6"
150-S-47	9300	21450	22.8	5.6	1750	28 x 28	80	4-6"	2-6"
160-S-47	10000	22950	22.8	5.6	1750	28 x 28	85	4-6"	2-6"
170-S-47	10710	24450	22.8	5.6	1750	28 x 32	90	4-6"	2-6"
180-S-47	11425	25950	26.1	6.0	2000	28 x 32	95	4-6"	2-6"
190-S-47	12125	27450	26.1	6.0	2000	28 x 32	100	4-6"	2-6"
200-S-47	12810	28950	26.1	6.0	2000	32 x 32	105	4-6"	2-6"
210-S-47	13500	30450	26.1	6.0	2000	32 x 32	110	4-6"	2-6"

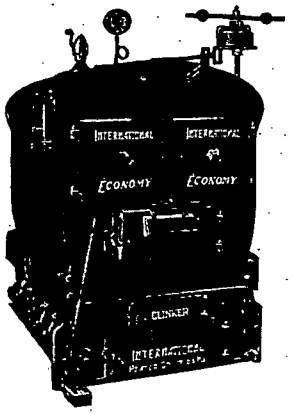
*Judgment should be used in fitting the boiler to a job. As an example: Do not attach a short boiler to a relatively high stack, or a long boiler to a relatively low stack. Suit the boiler to the job.

**All Economy Smokeless Boilers, 22" and 28" series, Nos. 70-S-34 to 100-S-34 and Nos. 61-S-47 to 91-S-47, inclusive, are built with grates extending full length of the boiler and using a mixing arch. All larger sizes are built as shown in catalog with bridge and wing walls.

†The Economy line of boilers does not require a header. Plug and bush tappings to size of mains.

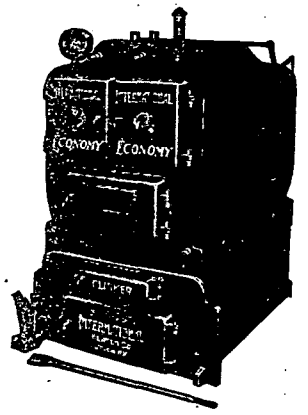
‡Send for Catalog 1751-G for additional data.

INTERNATIONAL HEATER COMPANY



Steam Pattern





Water Pattern

ECONOMY SECTIONAL BOILERS

Steam Pattern

Number	Guaranteed Radiation Load Sq. Ft.	Commercial Rating Sq. Ft.	Size of Grate Sq. Ft.	Additional Area Side Grates Sq. Ft.
4-S-19	427	915	3.1	2.1
5-S-19	568	1220	4.2	2.5
6-S-19	711	1525	5.2	2.9
4-S-22	497	1070	3.6	2.2
5-S-22	667	1435	4.9	2.6
6-S-22	837	1800	6.1	3.0
7-S-22	1008	2165	7.3	3.3
5-S-28	852	1830	6.2	3.0
6-S-28	1079	2320	7.7	3.3
7-S-28	1306	2800	9.3	3.7
8-S-28	1533	3300	10.9	4.1
5-S-34	1137	2440	7.5	3.3
6-S-34	1421	3050	9.4	3.6
7-S-34	1705	3660	11.3	4.0
8-S-34	1989	4270	13.2	4.4
9-S-34	2274	4880	15.1	4.7
10-S-34	2558	5490	17.0	5.1
6-S-47	3180	6890	16.3	4.7
7-S-47	3780	8190	19.5	5.1
8-S-47	4380	9490	22.8	5.6
9-S-47	4980	10790	26.1	6.0
10-S-47	5580	12090	29.3	6.5

SERIES	19"	22"	28"	34"	47"
Height of Water Line	44"	47"	50"	54"	59"
Height to Supply Outlets	53"	57"	62½"	68"	73"
Add to height for Trimmings	9"	11"	11"	11"	12"
Width of Ashpit	27"	29¾"	35"	40¾"	53"
Width of Boiler, including Trimmings	35"	39"	45"	54"	63"
Height from Floor to Center of Return Tappings	18"	19"	19½"	20"	21½"
Height of Fire Box to Crown	22"	22"	24"	26"	26"
Height, Grate to Middle of Feed Door	16"	16"	18"	18"	18"
Size of Feed Door	9x14"	9x17"	9x17"	11x21"	2-10x17"
Diameter of Smoke Flue	9"	12"	14"	16"	20"

Water Pattern

Number	Guaranteed Radiation Load Sq. Ft.	Commercial Rating Sq. Ft.	Size of Grate Sq. Ft.	Additional Area Side Grates Sq. Ft.
19-W-4	705	1525	3.1	2.1
19-W-5	937	2015	4.2	2.5
19-W-6	1173	2500	5.2	2.9
22-W-4	820	1760	3.6	2.2
22-W-5	1100	2365	4.9	2.6
22-W-6	1381	2970	6.1	3.0
22-W-7	1663	3570	7.3	3.3
28-W-5	1405	3020	6.2	3.0
28-W-6	1780	3825	7.7	3.3
28-W-7	2155	4630	9.3	3.7
28-W-8	2529	5435	10.9	4.1
W-34-W-5	1876	4026	7.5	3.3
W-34-W-6	2345	5002	9.4	3.6
W-34-W-7	2813	5978	11.3	4.0
W-34-W-8	3282	7076	13.2	4.4
W-34-W-9	3752	8052	15.1	4.7
W-34-W-10	4221	9028	17.0	5.1
47-W-6	5247	11375	16.3	4.7
47-W-7	6237	13520	19.5	5.1
47-W-8	7227	15665	22.8	5.6
47-W-9	8217	17810	26.1	6.0
47-W-10	9207	19955	29.3	6.5

SERIES	19"	22"	28"	34"	47"
Height to Supply Outlets	50"	54"	59"	68"	73"
Width of Boiler	33"	36"	42"	48"	59"
Height from Floor to Center of Return Tappings	18"	19"	19½"	20"	21½"
Height of Fire Box to Crown	22"	22"	24"	26"	26"
Height, Grate to Middle of Feed Door	16"	16"	18"	18"	18"
Size of Feed Door	9x14"	9x17"	9x17"	11x21"	2-10x17"
Width of Ashpit	27"	29¾"	35"	40¾"	53"
Diameter of Smoke Flue	9"	12"	14"	16"	20"

*Column No. 1 is our "Guaranteed Radiation Load" rating in direct cast iron radiation, as explained on preceding page.

Column No. 2 is our "Commercial" rating indicating our ratings based on tests made in accordance with the A. S. of H. & V. E Code. This is for comparison with boiler ratings of other manufacturers who use this as their rating basis.

INTERNATIONAL HEATER COMPANY

ECONOMY ROUND BOILERS

These Boilers are designed to meet the most rigid demands for economical heating.

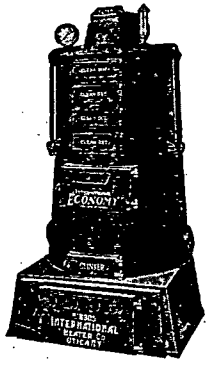
The carburetor principle of combustion is embodied in the design, also the positive cross fire travel, an exclusive feature of **Economy Round Boilers.**

Have deep firepot section, positive circulation, ample steam dome, individual cleanout doors, and side draft door.

Equipped with patented herring-bone triangular grate or flat grate for soft coal and the small sizes of anthracite coal.

Made in eighteen sizes, 18 to 30 in. grate diameters. Guaranteed radiation loads (steam): 187 to 166 sq. ft. of radiation, corresponding sizes for water.

See Catalog 1746-G for additional data.



Economy Round Water

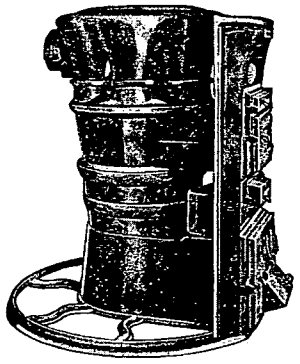
Data on ECONOMY ROUND BOILERS

Steam Pattern				Water Pattern			
Number	Ratings: Guaranteed Radiation Load Sq. Ft.	Ratings: Commercial Rating Sq. Ft.	Height Water Line Inches	Number	Ratings: Guaranteed Radiation Load Sq. Ft.	Ratings: Commercial Rating Sq. Ft.	Height to Flow Outlet Inches
3-E-18 and 32-E-18	187	525	41	18-E-3 and 18-E-32	309	900	40½
4-E-18 and 42-E-18	208	585	45	18-E-4 and 18-E-42	343	975	44½
5-E-18 and 52-E-18	229	645	49	18-E-5 and 18-E-52	378	1050	48½
B-221 and B-2221	193	540	43½	B-212 and B-2122	318	938	42¾
B-321 and B-3221	232	655	47½	B-213 and B-2132	383	1088	46½
B-421 and B-4221	267	760	51½	B-214 and B-2142	441	1238	50¾
B-224 and B-2224	250	710	44½	B-242 and B-2422	413	1200	43½
B-324 and B-3224	293	825	49	B-243 and B-2432	483	1388	48
B-424 and B-4224	333	950	53½	B-244 and B-2442	549	1575	52½
B-524 and B-5224	360	1015	58	B-245 and B-2452	594	1763	57
B-227 and B-2227	320	900	46¼	B-272 and B-2722	528	1538	45½
B-327 and B-3227	372	1050	51	B-273 and B-2732	614	1763	50¼
B-427 and B-4227	427	1200	55¾	B-274 and B-2742	705	1988	55
B-527 and B-5227	467	1315	60½	B-275 and B-2752	771	2213	59¾
B-230 and B-2230	467	1300	47½	B-302 and B-3022	771	2213	48
B-330 and B-3230	544	1530	52¾	B-303 and B-3032	898	2550	53¼
B-430 and B-4230	613	1725	58	B-304 and B-3042	1011	2888	58½
B-530 and B-5230	666	1875	63¼	B-305 and B-3052	1099	3150	63¾

SERIES	18″	21″	24″	27″	30″
Outside Diameter at Base	25½″	29″	32″	35″	39″
Height, Floor to Center Return Tappings	15¾″	16″	17″	17½″	17½″
Size of Smoke Flue	7″	9″	9″	10″	10″
Extreme Width of Firepot Section	23″	26½″	28⅜″	32¼″	35″
Tappings, Supply and Return	1–2½″	2–2½″	2–3″	2–3½″	2–4″

In the 18″ sizes the crown sheet is cast separate from firepot. In 21″, 24″, 27″ and 30″ sizes the firepot and crown sheet are cast in one piece.

INTERNATIONAL HEATER COMPANY



Carton Furnace

INTERNATIONAL CARTON FURNACE

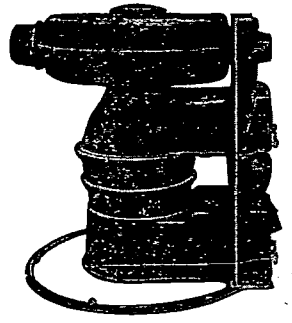
The **International Carton Furnace** is a sturdy, powerful heater made entirely of heavy cast iron with but five principal castings used in its assemblage.

It is very economical in the use of any fuel commonly used for heating purposes because of its *self cleaning* radiator.

Deep *sealed* cup joints are provided wherever castings join. The base and lower casing ring are in one piece, feed chute and combustion chamber are cast as a unit, and the ashpit is in one piece. Has patented herring-bone triangular grate, large double feed door, and roomy ashpit.

Made in six sizes. Firepot diameters 20 to 33 in. Casing diameters 44 to 60 in.

Complete Catalog 1818-G sent on request.



Economy Furnace

INTERNATIONAL ECONOMY FURNACE

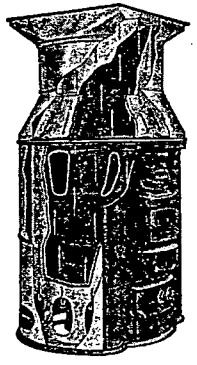
This is a moderate priced heater, but one of unusual efficiency. Proportions of heating surface, grate area and air capacity check with scientific and accepted standards.

The front is finished in a rich blue and surface grinding assures correct fit of contact joints.

The unique Economy radiator is totally different from any other and wide air spaces causes practically 50% of the air to pass toward the center over the hottest part of the fire. This heater has triangular grates, a big humidifier, large roomy ashpit, cold drop wire handles on both tight fitting feed and ashpit doors, and its ashpit, feed chute, and radiator openings extend thru the front so no smoke, gas, or dust can leak into the warm air chamber.

It is made in five sizes for hard or soft coal. Firepot diameters: 18 to 26 inches; casing diameters: 36 to 52 inches.

Complete data in catalog 1752-G.



Onepipe Heater

INTERNATIONAL ONEPIPE HEATER

The **International Onepipe Heater** is designed to deliver large volumes of warm air through one register correctly proportioned to firepot diameter.

The castings with the exception of special flanged front are the same as those used in the Baronet Furnace.

Heavy galvanized casings. *Inner casing triple lined* with heavy asbestos and corrugated tin. Both casings extend down to the rings which are integral with the base.

Top is adjustable to various heights without cutting.

Furnished with cast or steel radiator for hard or soft coal. Firepot diameters 16 to 24 in. Casing diameters 36 to 50 in., register sizes 24 x 24 in. to 40 x 40 in.

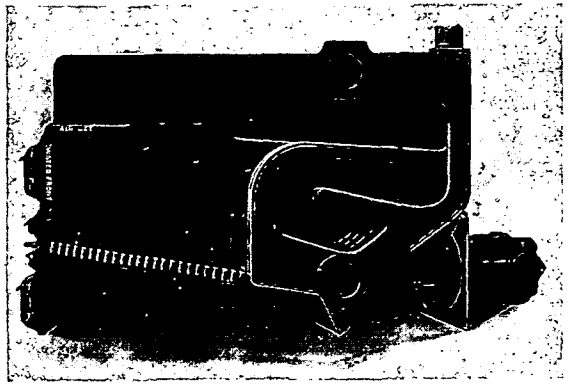
Complete data in Catalog 1610-G.

Special Types for Warming and Ventilating School Houses. Send for Bulletins 1505-G and 1757-G.

Ironton Bernhard Boiler Mfg. Co.

Ironton - Ohio

BERNHARD TRIPLE COMBUSTION BOILERS



Smokeless Boiler with the Lowest Water Line

The Consistent Boiler

The COMBUSTION from each Grate Bar being entirely taken care of in the Section directly above it, the same Ratio of GRATE Surface, FIRE Surface and FLUE Area is always maintained. Note how Gases Expand at three different points.

Boiler No.	Steam Rating	Water Rating	Grate Surface Sq. Ft.	Flue Area Through Sections Sq. In.	Lbs. Steam per Hour	B.t.u. per Hour	Height Water Line	Flow Openings
20- 5	600	1000	2.50	42	150	145,500	42"	2-3"
20- 6	800	1300	3.33	56	200	194,000	42"	2-3"
20- 7	1000	1650	4.17	70	250	242,500	42"	2-3"
20- 8	1200	2000	5.00	84	300	291,000	42"	2-3"
20- 9	1400	2350	5.84	98	350	339,500	42"	3-3"
30- 6	1600	2600	5.00	80	400	388,000	42"	2-4"
30- 7	2000	3250	6.25	100	500	485,000	42"	2-4"
30- 8	2400	3900	7.50	120	600	582,000	42"	2-4"
30- 9	2800	4550	8.75	140	700	679,000	42"	2-4"
30-10	3200	5200	10.00	160	800	776,000	42"	3-4"
30-11	3600	5850	11.25	180	900	873,000	42"	3-4"
30-12	4000	6500	12.50	200	1000	970,000	42"	3-4"
40- 8	4200	6720	10.00	160	1050	1,018,500	46"	2-5"
40- 9	4900	7840	11.66	185	1225	1,188,250	46"	2-5"
40-10	5600	8960	13.33	210	1400	1,358,000	46"	2-5"
40-11	6300	10080	15.00	235	1575	1,527,750	46"	2-5"
40-12	7000	11200	16.66	260	1750	1,697,500	46"	3-5"
40-13	7700	12320	18.33	285	1925	1,867,250	46"	3-5"
40-14	8400	13440	20.00	310	2100	2,037,000	46"	3-5"
40-15	9100	14560	21.66	335	2275	2,206,750	46"	3-5"
40-16	9800	15680	23.33	360	2450	2,376,500	46"	3-5"
40-17	10500	16800	25.00	385	2525	2,546,250	46"	4-5"
40-18	11200	17920	26.66	410	2800	2,716,000	46"	4-5"
40-19	11900	19040	28.33	435	2975	2,885,750	46"	4-5"
40-20	12600	20160	30.00	460	3150	3,055,500	46"	4-5"
40-21	13300	21280	31.66	485	3325	3,225,250	46"	4-5"
40-22	14000	22400	33.33	510	3500	3,395,000	46"	4-5"
*to	700	1120	1.67	25	175	169,750	....	.....
40-32	21000	33600	50.00	760	5250	5,092,500	46"	6-5"

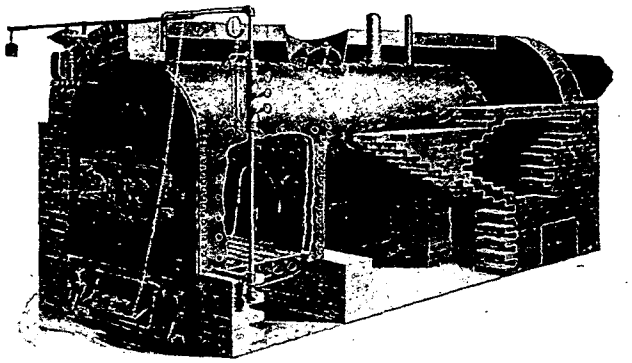
*Add per Section.

KEWANEE BOILER COMPANY

Kewanee, Illinois

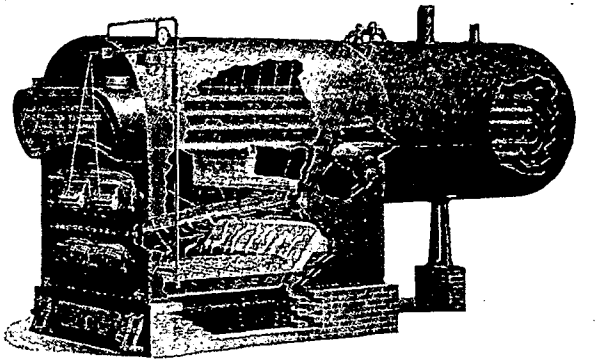
BRANCHES IN ALL PRINCIPAL CITIES

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 35 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*

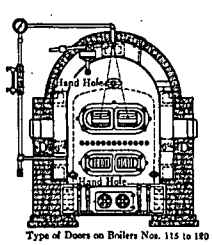
The rated capacity is the amount of direct radiation that the boiler will carry with a firing interval of three to four hours depending upon the grade of fuel used. No discount in rating is advised as reserve capacity has been allowed to care for the most severe weather conditions.

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.

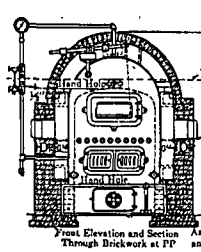
Ratings

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.

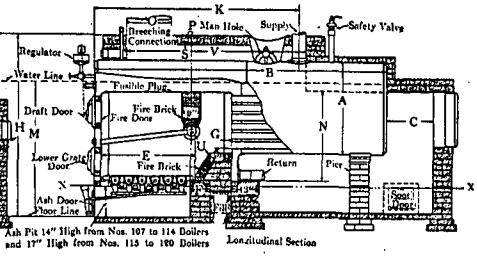
The ratings are based on a standard for steam of 2 lb. pressure at the boiler, and for water on a mean temperature of 180 deg. fahr. as the water leaves the boiler.



Type of Doors on Boilers Nos. 115 to 120



Front Elevation and Section Through Brickwork at PP

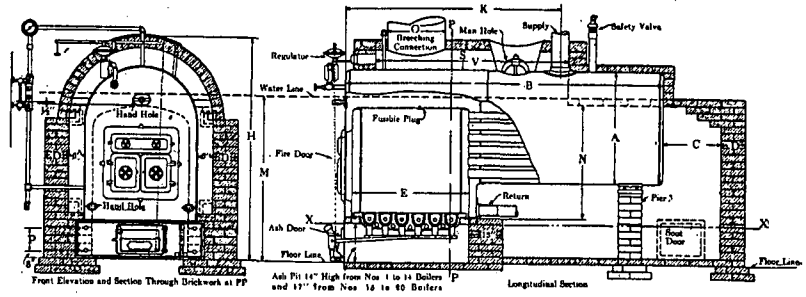


Ash Pit 14" High from Nos. 107 to 114 Boilers and 17" High from Nos. 115 to 120 Boilers — Longitudinal Section

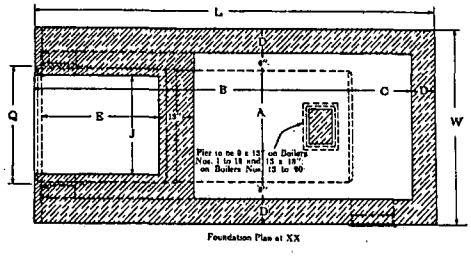
KEWANEE SMOKELESS BOILERS—BRICK-SET TYPE

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
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
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	7	7	7	7	7	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—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.



Front Elevation and Section Through Brickwork at PP — Ash Pit 14" High from Nos 1 to 14 Boilers and 17" from Nos 16 to 90 Boilers — Longitudinal Section

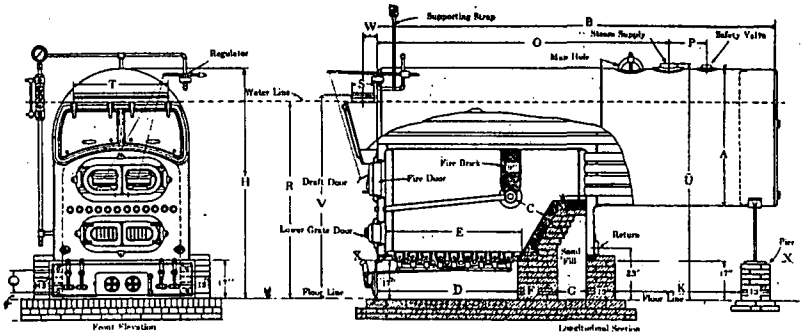


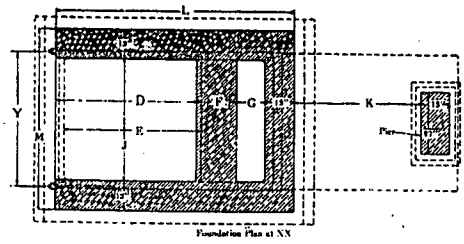
Foundation Plan at XX

KEWANEE FIREBOX BOILERS—BRICK-SET TYPE

Number of Boiler	1	2	3	4	5	6	8	9	10	11	12	13	14	15	16	17	18	19	20
Capacity, Steam....sq. ft.	900	1050	1200	1400	1700	2000	2600	3000	3500	4000	4500	5500	6500	7500	8700	10000	11000	12000	14000
Diameter of Boiler....in.	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.	6½	7½	8½	7½	9	10½	10	11½	10½	12	13½	14	16½	15½	18	16	18	16	18
Heating Surface....sq. ft.	113	131	147	160	215	250	305	350	368	420	472	560	673	743	873	954	1080	1167	1329
Area of Grate....sq. ft.	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.	12	14	16	16	18	18	20	22	22	24	24	28	28	32	32	32	32	36	36
Diameter of Stack....in.	12	12	14	14	16	16	18	20	20	22	22	26	26	30	30	30	30	34	34
Minimum Height of Stack....ft.	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.	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.	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.	45	45	45	45	45	45	50	50	50	50	50	55	60	60	70	70	70	70	70
Size of Steam Opening....in.	4	4	5	5	6	6	6	6	6	6	7	7	7	7	7	8	8	8	8
Size of Return....in.	2½	2½	3	3	3	3	4	4	4	5	5	5	5	5	5	6	6	6	6
Size of Safety Valve....in.	1¼	1¼	1¼	1½	1½	2	2	2	2	2½	2½	2½	3	3	3½	3½	3½	4	4
C—Rear Space....in.	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	13	13	13	13	13	13	13	13
E—Length Grate....in.	26	32	38	32	38	44	44	50	44	50	56	56	62	62	68	62	68	68	74
J—Width Ash-pit....in.	25	25	25	31	31	31	37	37	43	43	43	49	49	54	54	60	60	66	66
H—Total Height....in.	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	4-8	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.	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.	2-8	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.	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	7	7	7	7	7	8	8	8	8	8	10	10	10	10	10	10
V—Length of Arch....ft. in.	3-2	3-10	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	11	11	11	11	11	11
Q—Anchor Bolt Centers for Ash-pit Front....in.	30	30	30	36	36	36	42	42	48	48	48	54	54	60	60	66	66	72	72
L—Total Length....ft. in.	8-7	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.	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	1450	1600	1750	1900	2150	2400	2650	2900	3000	3300	3600	5300	5900	6500	7200	7200	7700	7700	8200
*Common Brick for Two Boilers	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.

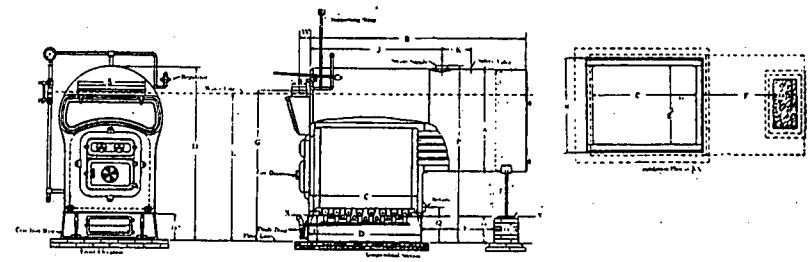




KEWANEE SMOKELESS BOILERS—PORTABLE TYPE

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
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
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	7	7	7	7	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	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	15	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

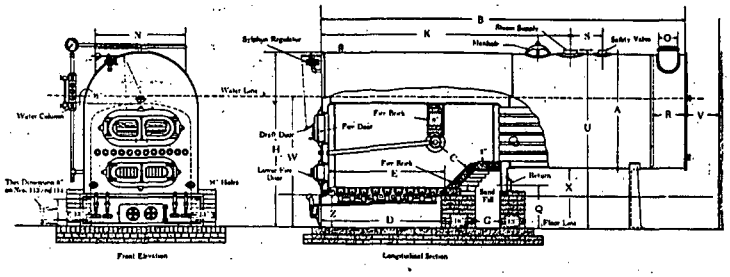
*Foundations not included.. †If space is available at front, it is not necessary at rear, and vice-versa.

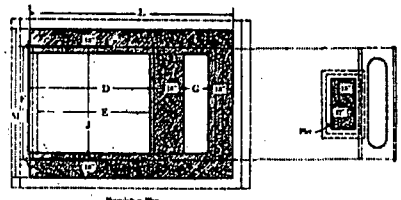


KEWANEE BOILERS—PORTABLE TYPE

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
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
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	7	7	7	7	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	27	18	30	18	24	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.

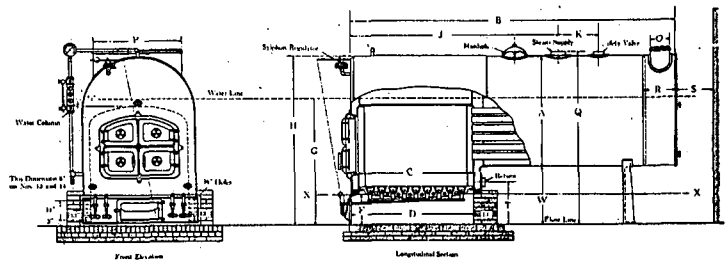


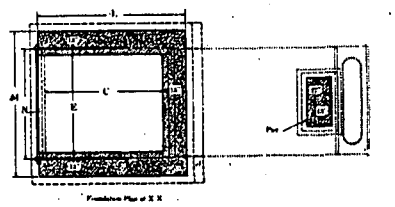


KEWANEE PORTABLE SMOKELESS BOILERS TYPE K

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
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
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	7	7	7	7	7	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	32	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	19	19	19	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.	47	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	36	36	36	42	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
Height of Stack....ft.	35	35	35	35	35	35	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
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	7	7	7	7	7	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.		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	26¾	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.	18	18	18	18	19	19	19	19	19	19	19	19	19	19	23	23	23	23	23	23
W—Floor Line to Bottom of Cylinder....in.		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.

Lebanon Boiler Works

J. K. PETTY & CO., Inc., Proprietors

1210 Buttonwood Street - Lebanon, Pa.

Sales Offices
507 Harrison Building, PHILADELPHIA

KOITHAN & PRYOR, Representatives
39 Cortlandt Street, NEW YORK

Representatives in Other Principal Cities

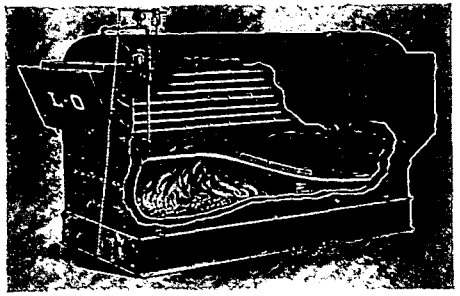
For Larger Buildings

Lebanon "L-O" Steel Boilers

Built also for high-pressure service up to 400 horsepower.

The standard unit is shipped complete with steel base, grates, bridgewall and refractory combustion arch securely attached to the boiler, ready for operation. The boiler is skidded on its own base.

For **Oil Firing** the burner is generally located in base at rear, bridgewall is omitted, and combustion arch on top of furnace water circulating tubes is extended to rear head.

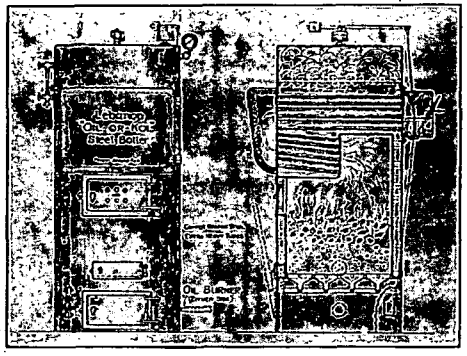


Boiler No.	Steam Radiation (Sq. Ft.) Coal	Steam Radiation (Sq. Ft.) Oil Fuel	Boiler Dimensions Width x Height above Floor x Length
LO-15	3,200	4,000	44" x 71" x 6'
LO-16	4,000	5,000	44" x 71" x 7'
LO-17	4,800	6,000	50" x 79" x 7'
LO-18	5,600	7,000	50" x 79" x 8'
LO-19	6,400	8,000	50" x 79" x 8'
LO-110	7,200	9,000	56" x 86" x 8'
LO-111	8,000	10,000	56" x 86" x 9'
LO-112	9,600	12,000	56" x 86" x 10'
LO-113	11,200	14,000	62" x 91" x 9'
LO-114	12,800	16,000	62" x 91" x 10'
LO-115	14,400	18,000	62" x 91" x 11'
LO-116	16,000	20,000	68" x 97" x 11'
LO-117	20,000	25,000	68" x 100" x 12'
LO-118	24,000	30,000	68" x 106" x 12'
LO-119	28,000	35,000	74" x 109" x 13'
LO-120	32,000	40,000	74" x 113" x 14'
LO-121	36,000	45,000	74" x 117" x 15'
LO-122	40,000	50,000	80" x 118" x 14'

For Homes and Small Buildings

Lebanon "Oil-or-Kol" Steel Boilers

Steam, Vapor or Water Heating



Boiler No.	Steam Radiation Sq. Ft. **Hard Coal Sq. Ft.	Steam Radiation Sq. Ft. Oil Fuel Sq. Ft.	Boiler Dimensions Diam. x Hgt. Inches
*OK-118	300	375	18 x 57
*OK-121	400	500	21 x 57
*OK-124	550	700	24 x 60
*OK-127	750	925	27 x 63
*OK-130	1000	1250	30 x 63
OK-133	1300	1625	33 x 66
OK-136	1650	2050	36 x 66
OK-139	2050	2550	39 x 72
OK-142	2500	3125	42 x 72

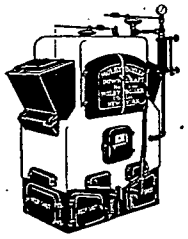
*Small-doorway sizes.
**For Soft Coal the next larger size boiler is recommended.

Molby Boiler Company

INCORPORATED

41 East 42nd Street, New York **Plant: Lansdale, Pa.**

Molby Magazine-Feed Downdraft-Crossdraft Boilers and Tank Heaters with Adjustable Side Grate for Burning No. 1 Buckwheat Anthracite



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.

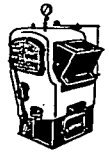
Side grate easily adjusted for any size of coal.

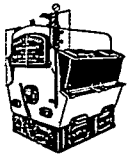
The MOLBY Boiler is self-coaling and gives a steady, even heat over long periods with low-priced No. 1 Buckwheat Anthracite. Also burns sized free-burning bituminous with proper chimney draft. Also coke. Magasines need re-filling only every 12 hours. Cast iron sectional construction throughout.

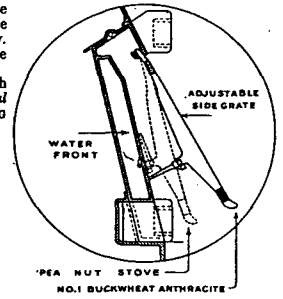
Ratings are based on the assumption that a good grade of No. 1 Buckwheat Anthracite is to be used and that the chimney is of such area, height and tightness as to produce the required draft; also that the boiler, mains and connections shall be covered with an insulating material. These ratings, under the same conditions, may be used for sized soft coal which must be free-burning and non-caking.

Should larger sizes of good grades of Anthracite be used, a given boiler—other conditions being the same—would burn more coal with equal efficiency. Thus, when such larger sizes are regularly used, the ratings shown are increased.

The boiler is built throughout in accordance with the codes of the *American Society of Mechanical Engineers* and the AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS.







SIZES, CAPACITIES, DIMENSIONS AND PRICES

Number	Steam Vapor	Steam Water Line	Steam Returns	Steam Steam Rating	Steam List Price	Steam and Water Size—Inches Height	Width	Length	Smoke Pipe	Outlets	Chimney Flue	Approximate Shipping Weight	Water Number	Water Cipher	Water Return	Water Water Rating	Water List Price
25" Series																	
S-4026	Adageo	48	2-3	500	$ 407.00	54	41	35½	10	2-3	8x12	1890	W-4026	Domo	2-3	850	$379.74
S-5026	Addieo	48	2-3	675	492.14	54	41	42	10	2-3	8x12	2230	W-5026	Doseo	2-3	1125	461.99
S-6026	Admito	48	2-3	850	577.28	54	41	48½	10	2-3	8x12	2580	W-6026	Doffo	2-3	1400	544.22
S-7026	Adzo	48	2-3	1025	662.42	54	41	55	10	2-3	12x12	2950	W-7026	Doveo	2-3	1700	626.46
S-8026	Adelo	48	2-3	1200	747.56	54	41	61½	10	2-3	12x12	3300	W-8026	Docko	2-3	2000	708.69
31" Series																	
S-4031	Bugo	54	2-4	1000	681.45	62½	61	37⅝	14	2-3	8x12	3320	W-4031	Edamo	2-4	1650	658.71
S-5031	Buffo	54	2-4	1350	837.54	62½	61	44	14	2-3	12x12	3820	W-5031	Edgeo	2-4	2250	809.48
S-6031	Bullo	54	2-4	1700	960.99	62½	61	50⅜	14	2-3	12x12	4290	W-6031	Edito	2-4	2850	928.73
S-7031	Buno	54	2-4	2050	1169.58	62½	61	56¼	14	3-3	12x16	4690	W-7031	Edicto	2-4	3425	1130.21
S-8031	Bulbo	54	2-4	2400	1297.29	62½	61	63⅛	14	3-3	12x16	5100	W-8031	Edeno	2-4	4000	1253.57
S-9031	Buoyo	54	2-4	2750	1410.81	62½	61	69⅛	14	3-3	16x16	5510	W-9031	Educeo	2-4	4575	1363.22
S-10031	Bungo	54	2-4	3100	1524.33	62½	61	75⅝	14	3-3	16x16	5930	W-10031	Eduxo	2-4	5150	1472.87
47" Series																	
S-5047	Calxo	67½	2-5	2550	1384.82	80	75½	50½	14	2-4	12x16	5990	W-5047	Fluxo	2-5	4250	1338.38
S-6047	Calfo	67½	2-5	3200	1611.86	80	75½	59	14	2-4	16x16	7150	W-6047	Fledo	2-5	5325	1557.68
S-7047	Caro	67½	3-5	3850	1838.90	80	75½	67½	16	3-4	16x16	8310	W-7047	Flipo	3-5	6400	1776.98
S-8047	Carpo	67½	3-5	4500	2065.94	80	75½	76	16	3-4	16x20	9500	W-8047	Flowo	3-5	7500	1996.28
S-9047	Caseo	67½	3-5	5150	2292.98	80	75½	84½	18	3-4	16x20	10650	W-9047	Flungo	3-5	8575	2215.58
S-10047	Cadio	67½	3-5	5800	2520.02	80	75½	93	18	4-4	20x20	11840	W-10047	Flusho	3-5	9650	2434.88
S-11047	Cabo	67½	3-5	6450	2775.44	80	75½	101½	18	4-4	20x20	13000	W-11047	Flinto	3-5	10725	2681.60
S-12047	Cando	67½	3-5	7100	3002.48	80	75½	110	18	4-4	20x24	14150	W-12047	Flato	3-5	11800	2900.90
S-13047	Camo	67½	3-5	7750	3229.52	80	75½	118½	18	4-4	20x24	15320	W-13047	Fleigo	3-5	12925	3120.20

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.

NATIONAL RADIATOR COMPANY

General Offices: JOHNSTOWN, PA.

NEW YORK, 47 W. 42nd Street
PHILADELPHIA, 121 N. Broad Street
BALTIMORE, 2622 Frisby Street
WASHINGTON, 2205 Fifth St., N.E.

Branches

RICHMOND, 3032 Norfolk Street
PITTSBURGH, 1402 Arrott Building
CLEVELAND, 6308 Kinsman Road
CINCINNATI, Cor. Spring Grove and Elmira Aves.
CHICAGO, 1038 S. Kolmar Ave.

Plants

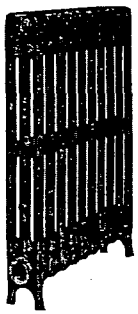
JOHNSTOWN, PA. — NEW CASTLE, PA. — TRENTON, N. J.

Warehouses

NEW YORK — NEW ROCHELLE — BALTIMORE — WASHINGTON — RICHMOND
CLEVELAND — CINCINNATI — CHICAGO

Manufacturers

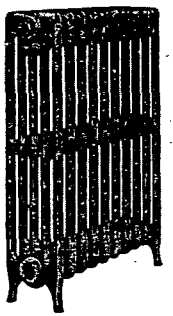
National Smokeless, Novus Upright and Sectional, Acme Round, Radium Gas and Hot Water Supply Boilers, also Aero Radiators.



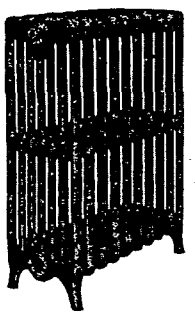
Three-Column



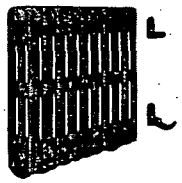
Four-Column



Five-Column



Seven-Column



Legless Radiator

Patents Applied For

AERO RADIATORS

The Aero Radiator was designed by Engineers with more than 30 years experience in radiator manufacture. In the Aero line is represented a real effort to simplify the multiplicity of radiator patterns and heights.

Large buildings are now warmed with the more modern, efficient, economical and easily controlled vapor and vacuum systems. These necessitate the use of a radiator pattern with top and bottom nipple connection—the type known as a water section. The demand for the straight steam section, with bottom nipple connection only, is consequently negligible.

The Aero Radiator is made in one type only—the top and bottom nipple connected section.

It is tapped top and bottom both ends. The top tappings are plugged and the bottom tappings bushed to size required.

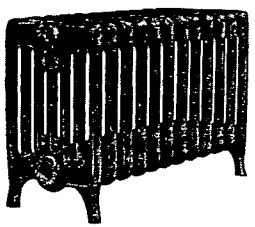
All radiators are vented for both steam and hot water. One vent is plugged. Any Aero Radiator can be used for either steam, hot water or vapor.

Aero Radiators are made in four patterns—Three, Four, Five and Seven Column. A total of 18 heights comprises the entire line.

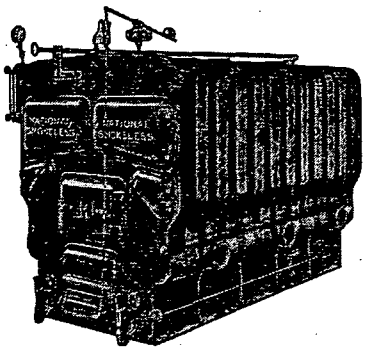
Roughing-in measurements are standard. All sections measure 2½ in. from center to center.

The Three-Column pattern is 5¼ in. wide, the Four Column is 6⅝ in. wide, the Five-Column pattern 8⅜ in. wide and the Seven-Column pattern 12 in. With these widths and standard roughing-in measurements they can be used on any standard specification.

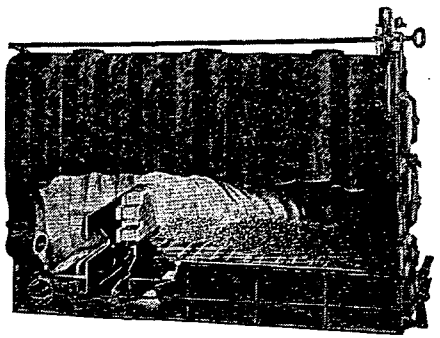
Aero radiators are sold at the same standard sheet price as the old radiator types.



Window Radiator



National Smokeless Boiler

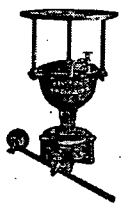


Sectional View

Patented

LIST PRICES AND RATING

Size	Steam Rating	Water Rating	Number Sections	Number Grates	Grate Area sq. ft.	Combustion Chamber Area sq. ft.	Height Water Line Inches	Height Top Outlets Inches	Height Including Trimmings	Width Boiler Inches	Width Including Trimmings Inches	Length Including Smokehood Inches	Size Base Inches	Outlets No. and Size	Size Smoke Pipe
25- 9	2525	4175	9	5	6.11	3.48	49	57¼	65⅝	36½	40¾	74⅝	27/8x 60⅝	3-4"	12
25-10	2825	4675	10	6	7.27	3.48	49	57¼	65⅝	36½	40¾	81⅝	27/8x67⅝	3-4"	12
25-11	3125	5175	11	7	8.43	3.48	49	57¼	65⅝	36½	40¾	88⅝	27/8x74⅝	3-4"	12
25-12	3425	5675	12	8	9.59	3.48	49	57¼	65⅝	36½	40¾	95⅝	27/8x 81⅝	3-4"	12
31- 9	3625	5975	9	5	8.55	5.07	52	61	71¼	50	54	79¼	33¾x 65¼	3-5"	15
31-10	4050	6675	10	6	10.24	5.07	52	61	71¼	50	54	88	33¾x 74	3-5"	15
31-11	4475	7375	11	7	11.93	5.07	52	61	71¼	50	54	95½	33¾x 81½	3-5"	15
31-12	4900	8075	12	8	13.62	5.07	52	61	71¼	50	54	103	33¾x 89	3-5"	15
31-13	5325	8775	13	9	15.31	5.07	52	61	71¼	50	54	110½	33¾x 96½	3-5"	15
36- 9	5125	8475	9	5	11.50	6.75	60¼	70	78¾	56	60	87½	41⅜x 73½	3-5"	16
36-10	5750	9500	10	6	13.75	6.75	60¼	70	78¾	56	60	95⅞	41⅜x 81⅞	3-5"	16
36-11	6375	10,525	11	7	16.00	6.75	60¼	70	78¾	56	60	104¼	41⅜x 90¼	3-5"	16
36-12	7000	11,550	12	8	18.25	6.75	60¼	70	78¾	56	60	112⅝	41⅜x 98⅝	3-5"	16
36-13	7625	12,575	13	9	20.50	6.75	60¼	70	78¾	56	60	121	41⅜x107	4-5"	16
36-14	8250	13,600	14	9	20.50	9.50	60¼	70	78¾	56	60	129⅜	41⅜x115⅜	4-5"	16
36-15	8875	14,625	15	10	22.75	9.50	60¼	70	78¾	56	60	137¾	41⅜x123¾	4-5"	16
36-16	9500	15,650	16	10	22.75	12.25	60¼	70	78¾	56	60	146⅛	41⅜x132⅛	4-5"	16
48- 9	9200	15,100	9	5	18.23	10.65	68	80	89	67	71	109¼	53⅞x 89¼	3-6"	20
48-10	10,325	16,950	10	6	21.78	10.65	68	80	89	67	71	119⅞	53⅞x 99⅞	3-6"	20
48-11	11,450	18,800	11	7	25.33	10.65	68	80	89	67	71	130½	53⅞x110½	4-6"	20
48-12	12,575	20,650	12	8	28.88	10.65	68	80	89	67	71	141⅛	53⅞x121⅛	4-6"	20
48-13	13,700	22,500	13	9	32.43	10.65	68	80	89	67	71	151¾	53⅞x131¾	5-6"	20
48-14	14,825	24,350	14	9	32.43	14.20	68	80	89	67	71	162⅜	53⅞x142⅜	5-6"	20
48-15	15,950	26,200	15	10	35.98	14.20	68	80	89	67	71	173	53⅞x153	5-6"	20
48-16	17,075	28,050	16	10	35.98	17.75	68	80	89	67	71	183⅝	53⅞x163⅝	5-6"	20



Sylph-Oil Air Regulator Patents Applied For

The National Up-Draft Smokeless Boiler will conform to any smoke ordinance.

Burning smoke depends upon the temperature to which the air discharged over the fire is preheated. The National Preheating Air device heats air to in excess of 1000 deg. It is discharged into the smoke and gases as they pass over the Refractory Bridge wall into the Combustion Chamber.

The National Smokeless Boiler will clear to the No. 1 Smoke Screen in from 10 to 15 seconds and to a clear stack in less than one minute after firing a charge of green coal.

National Smokeless boilers show an average increase of 28 per cent in evaporation on the same fuel charge and consequently are very economical in operation.

The volume of preheated air necessary to burn smoke varies with the state of combustion. The air should be gradually decreased and cut off almost completely during a period of about 20 minutes from the time fuel is charged. Unless this is done the preheated air has a tendency to chill rather than increase the gas temperatures and the boiler efficiency and evaporation is decreased.

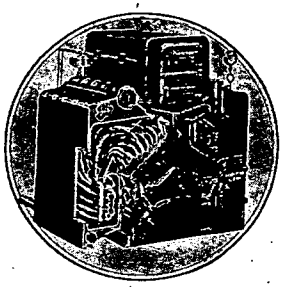
The Sylph-Oil Regulator operates the Preheating Air Device automatically and positively can be regulated to close the air intake in any time from one half-a minute to one hour after fuel is charged.

Newport Boiler Company

CHICAGO

General Offices: 529 S. Franklin Street

MAGAZINE FEED



OIL BURNING

SAVES HOURS OF TIME AND TONS OF COAL

Heating expenses may be reduced about 50 per cent, by burning No. 1 Buckwheat coal which contains approximately the same heat value as the larger, more expensive sizes.

Patented Newport features make possible the use of practically all kinds of Fuel Coal—Coke—Oil and Gas.

This modern heater, highly economical, eliminates the drudgery of frequent attention, required in the operation of ordinary surface feed boilers, and offer as well unmatched convenience, uniform heat for long periods without attention, consistently meeting present day demands.

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	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	62¼"	56"	16 x 16	50
S-99	2625	1500	W-99	4313	2464	69"	56"	16 x 16	50

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	62¼"	56"	16 x 16	50
O-S-99	2625	1500	O-W-99	4313	2464	69"	56"	16 x 16	50

*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) pound of steam, per square foot per hour.

The water line on all Steam Boilers is 40⅕ inches.

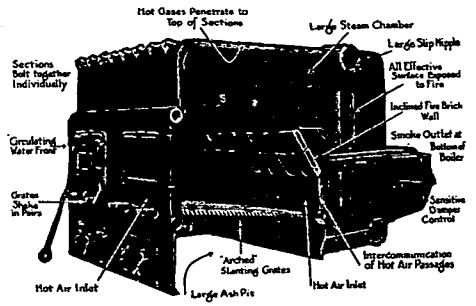
Height over all Coal Boilers 62 inches—Oil Boilers 48¾ inches.

NIAGARA RADIATOR AND BOILER COMPANY

Main Offices

North Tonawanda, N. Y.

NEW YORK CITY—2051 Grand Central Terminal
CHICAGO—1111 East 83rd Street
PHILADELPHIA—121 North Broad Street
CLEVELAND—2036 East 105th Street
PITTSBURGH—304 Oliver Building

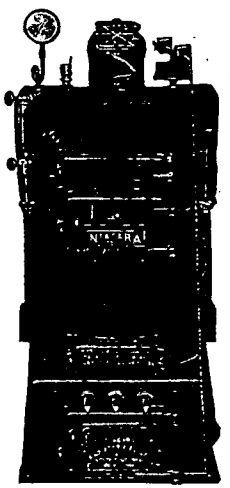


Niagara Smokeless Boilers

Made in 31 sizes for Steam or Water.

1600 to 14,250 sq. ft. in Steam

2650 to 23,700 sq. ft. in Water



Niagara Round Boilers

Made in 21 sizes for steam or water having TRIANGULAR or FLAT Grates.

300 to 1450 sq. ft. in steam
500 to 2400 sq. ft. in water

Also **Hot Water Supply Boilers**



Niagara Column Radiation

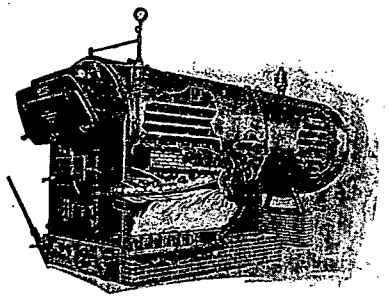
Made in 1-2-3-4-6-Window Seat Pin and Prime Indirect patterns.



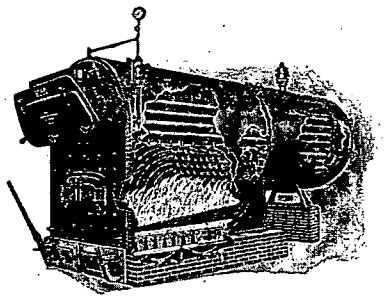
Niagara Wall Radiation
5-7-9 sq. ft. patterns

OIL CITY BOILER WORKS — Oil City ~ Pa.

NEW YORK, N. Y., 501 Fifth Ave.
PHILADELPHIA, PA., 1043 Real Estate Trust Bldg.
PITTSBURGH, PA., 1116 House Bldg.
ATLANTA, GA., 315 Glenn Bldg.
BALTIMORE, MD., Dukehart Bldg.
INDIANAPOLIS, IND., 117 East Michigan St.
DETROIT, MICH., 715 Donovan Bldg.
SAN FRANCISCO, CALIF., 417 Market St.
CHICAGO, ILL., 19 W. Jackson Blvd.
LOS ANGELES, CALIF., 1003 Union Trust Bldg.
WINSTON-SALEM, N. C., 236 Liberty St.
CINCINNATI, O., S. W. Cor. 3rd and Walnut Sts.
RICHMOND, VA., American National Bank Bldg.



"Oil City" Direct Draft Boiler



"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.

All parts of the boiler are made accessible for cleaning by the use of manholes, handholes, and wash-out plugs.

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.

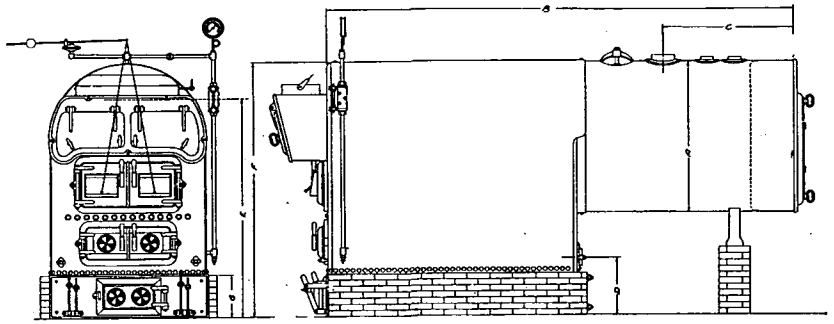
Equipment—Equipment with all boilers includes, in addition to complete set of shaking grates, all the necessary castings, safety valves, steam gauge, water column, etc., required for a complete installation.

Oil Fired—Where oil is used exclusively we recommend our new Series 9000 Portable Return Tubular Fire Box Oil Burning Boiler. Complete specifications and measurements shown in Circular H-18.

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.

SPECIFICATIONS AND GENERAL DIMENSIONS ON NEXT PAGE.



Settling Plan and Measurements "Oil City" Heating Boilers

"Oil City" Smokeless

NUMBER OF BOILER			807	808	809	810	811	812	813	814	815	816	817	818	819	820	821	822	823	824
CAPACITY - STEAM		Sq. Ft.	3000	3500	4000	4500	5000	5500	6000	6500	7000	7500	8000	8500	9000	9500	10000	10500	11000	11500
CAPACITY - WATER		Sq. Ft.	3000	3500	6600	7400	8300	9100	9900	10700	11400	12200	13000	13800	14500	15400	16200	17000	17800	18600
BOILER DIAMETER	A	In.	48	48	48	54	54	54	60	60	60	60	66	66	72	72	72	78	84	84
BOILER LENGTH	B	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	20-4	21-4
REAR TO OUTLET	C	Ft. & In.	3-2	3-9	4-2	3-5	3-9	4-2	4-2	4-8	4-8	4-9	4-9	4-8	5-0	5-9	5-8	6-1	6-5	6-9
FLOOR TO RETURN	D	In.	19	19	19	19	19	19	22½	22½	22½	22½	23	23	23	23	23	23	23	23
FLOOR TO WATER LINE	E	In.	71	71	71	76	76	76	87	87	87	87	90	90	96	96	97	97	105	105
HEIGHT OVER BOILER	F	Ft. & In.	7-0	7-0	7-0	7-5	7-5	7-5	8-5	8-5	8-5	8-5	8-11	8-11	9-5	9-5	9-7	9-7	10-1	10-1
HEIGHT ASH PIT	G	Ft. & In.	14	14	14	14	14	14	17	17	17	17	17	17	17	17	17	17	17	17
SIZE OUTLET		In.	6	6	6	6	6	6	7	7	7	7	8	8	8	8	8	8	10	10
SIZE RETURN		In.	4	4	4	4	4	4	5	5	5	5	6	6	6	6	6	6	8	8
SIZE SMOKE OUTLET		In.	10-36	10-36	10-36	10-42	10-42	10-42	12-40	12-40	12-40	12-40	15-30	15-30	17-34	17-34	17-60	17-60	20-64	20-64
DIA. BREECHING - ONE BOILER		In.	22	22	22	24	24	24	26	26	28	28	30	32	34	34	36	36	40	42
DIA. BREECHING - TWO BOILERS		In.	30	30	30	34	34	34	36	36	40	40	44	46	50	50	52	52	56	58
DIA. STACK - ONE BOILER		In.	20	20	20	22	22	22	24	24	26	26	28	30	32	32	34	34	38	40
DIA. STACK - TWO BOILERS		In.	28	28	28	31	31	31	34	34	36	36	40	42	46	46	48	48	54	56
HEIGHT STACK - ONE BOILER		Ft.	50	55	55	55	55	60	60	60	65	65	70	70	70	70	80	80	90	100
HEIGHT STACK - TWO BOILERS		Ft.	60	65	65	65	65	70	70	70	75	75	75	80	80	80	90	100	100	110
REQ'D TO OPEN REAR DOORS		In.	26	26	26	28	28	28	32	32	32	32	35	35	37	37	40	40	43	43

"Oil City" Direct Draft Type

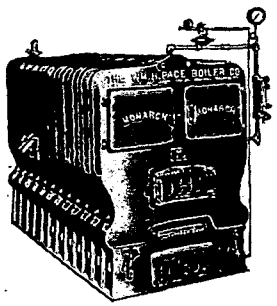
NUMBER OF BOILER			907	908	909	910	911	912	913	914	915	916	917	918	919	920	921	922	923	924
CAPACITY - STEAM		Sq. Ft.	2500	3000	3500	4000	4500	5000	5500	6000	7000	8000	9000	10000	13000	15000	17500	20000	25000	30000
CAPACITY - WATER		Sq. Ft.	4800	5800	5800	6600	7400	8300	9000	9900	11600	13200	15000	16700	21500	24800	28500	32000	40000	48000
BOILER DIAMETER	A	In.	48	48	48	54	54	54	60	60	60	60	66	66	72	72	78	78	84	84
BOILER LENGTH	B	Ft. & In.	8-7	9-6	11-1	10-0	11-1	12-1	12-5	13-7	14-9	16-2	15-9	17-9	15-11	17-6	17-11	19-11	20-1	22-1
REAR TO OUTLET	C	Ft. & In.	3-11	4-3	4-10	4-7	4-9	4-9	4-1	4-2	4-11	5-11	6-3	6-5	7-2	6-3	6-5	6-8	7-11	7-7	9-7
FLOOR TO RETURN	D	In.	19	19	19	19	19	19	22½	22½	22½	22½	23	23	23	23	23	23	23	23
FLOOR TO WATER LINE	E	In.	71	71	71	76	76	76	87	87	87	87	90	90	96	96	97	97	105	105
HEIGHT OVER BOILER	F	Ft. & In.	7-0	7-0	7-0	7-5	7-5	7-5	8-5	8-5	8-5	8-5	8-11	8-11	9-5	9-5	9-7	9-7	10-1	10-1
HEIGHT ASH PIT	G	Ft. & In.	14	14	14	14	14	14	17	17	17	17	17	17	17	17	17	17	17	17
SIZE OUTLET		In.	6	6	6	6	6	6	7	7	7	7	8	8	8	8	8	8	10	10
SIZE RETURN		In.	4	4	4	4	4	4	5	5	5	5	6	6	6	6	6	6	8	8
SIZE SMOKE OUTLET		In.	10-36	10-36	10-36	10-42	10-42	10-42	12-40	12-40	12-40	12-40	15-30	15-30	17-34	17-34	17-60	17-60	20-64	20-64
DIA. BREECHING - ONE BLR.		In.	22	22	22	24	24	24	26	26	28	28	30	32	34	34	36	36	40	42
DIA. BREECHING - TWO BLRS.		In.	30	30	30	34	34	34	36	36	40	40	44	46	50	50	52	52	56	58
DIA. STACK - ONE BLR.		In.	20	20	20	22	22	22	24	24	26	26	28	30	32	32	34	34	38	40
DIA. STACK - TWO BLRS.		In.	28	28	28	31	31	31	34	34	36	36	40	42	46	46	48	48	54	56
HEIGHT STACK - ONE BLR		Ft.	50	50	55	55	55	60	60	60	65	65	65	70	70	70	80	80	90	100
HEIGHT STACK - TWO BLRS.		Ft.	60	60	65	65	65	70	70	70	75	75	75	80	80	80	90	100	100	110
REQ'D TO OPEN REAR DOORS		In.	26	26	26	28	28	28	32	32	32	32	35	35	37	37	40	40	43	43

THE WM. H. PAGE BOILER CO.

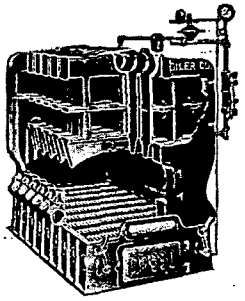
200 Madison Avenue, NEW YORK

BOSTON, 123 Beverly Street
PHILADELPHIA, 1718 Sansom Street
CLEVELAND, Rose Building
MEADVILLE, PA., Factory

Makers of Boilers for more than Half a Century



Monarch Smokeless



Monarch Water Tube

Monarch Sectional Steam and Water Boilers

Number	Commercial Rating* Sq. Ft. Steam	Page Safe Rating★ Sq. Ft. Steam	Size of Grate, Inches	Area of Grate, Sq. Ft.	Height Over All, Inches, Steam	Width Over All, Inches, Steam	Height Over All, Inches, Water	Width Over All, Inches, Water	Total Length, Inches	Water Line, Inches, Steam	Outlets and Inlets, Inches	Size of Smoke Pipe, Inches
604	850	650	22x20	3.06	60½	39¼	52	35	35¼	41	2-3	13
605	1075	850	22x26⅜	4.03	60½	39¼	52	35	41⅜	41	2-3	13
606	1300	1050	22x32¾	5.00	60½	39¼	52	35	48	41	2-3	13
607	1525	1250	22x39⅛	5.98	60½	39¼	52	35	54⅜	41	2-3	13
504	1600	1200	28x24¼	4.82	73	45¼	64½	41	44⅞	51	2-5	15
505	2100	1600	28x33⅛	6.45	73	45¼	64½	41	53¼	51	2-5	15
506	2600	2000	28x41½	8.07	73	45¼	64½	41	61⅝	51	2-5	15
507	3100	2400	28x49⅞	9.70	73	45¼	64½	41	70	51	2-5	15
508	3600	2800	28x58¼	11.32	73	45¼	64½	41	78⅜	51	2-5	15
509	4100	3200	28x66⅝	12.96	73	45¼	64½	41	86¾	51	2-5	15
405	3400	2400	40x33⅛	9.20	81	59¼	72½	55	52	58	2-5	21
406	4200	3000	40x41½	11.52	81	59¼	72½	55	60⅜	58	2-5	21
407	5000	3600	40x49⅞	13.85	81	59¼	72½	55	68¾	58	2-5	21
408	5800	4200	40x58¼	16.18	81	59¼	72½	55	77⅛	58	2-5	21
409	6600	4800	40x66⅝	18.50	81	59¼	72½	55	85½	58	2-5	21
410	7400	5400	40x75	20.82	81	59¼	72½	55	93⅞	58	2-5	21
411	8200	6000	40x83⅜	23.13	81	59¼	72½	55	102¼	58	3-5	21
412	9000	6600	40x91¾	25.50	81	59¼	72½	55	110⅝	58	3-5	21
6-60	6600	4800	60x41½	17.29	82¼	85⅜	74¼	81⅛	64⅜	60	2-6	26
7-60	8200	6000	60x49⅞	20.78	82¼	85⅜	74¼	81⅛	72¼	60	2-6	26
8-60	9800	7200	60x58¼	24.27	82¼	85⅜	74¼	81⅛	81⅛	60	2-6	26
9-60	11400	8400	60x66⅝	27.76	82¼	85⅜	74¼	81⅛	89½	60	3-6	26
10-60	13000	9600	60x66⅝	31.25	82¼	85⅜	74¼	81⅛	97⅞	60	3-6	26
11-60	14600	10800	60x66⅝	34.74	82¼	85⅜	74¼	81⅛	106¼	60	3-6	26
12-60	16200	12000	60x75	38.22	82¼	85⅜	74¼	81⅛	114⅝	60	3-6	26
13-60	17800	13200	60x75	41.72	82¼	85⅜	74¼	81⅛	123	60	3-6	26
14-60	19400	14400	60x75	45.20	82¼	85⅜	74¼	81⅛	131⅜	60	3-6	26
15-60	21000	15600	60x83⅜	48.69	82¼	85⅜	74¼	81⅛	139¾	60	3-6	26
16-60	22600	16800	60x83⅜	52.18	82¼	85⅜	74¼	81⅛	148⅛	60	3-6	26
17-60	24200	18000	60x83⅜	55.67	82¼	85⅜	74¼	81⅛	156½	60	3-6	26
18-60	25800	19200	60x91¾	59.16	82¼	85⅜	74¼	81⅛	164⅞	60	3-6	26
19-60	27400	20400	60x91¾	62.65	82¼	85⅜	74¼	81⅛	173¼	60	3-6	26
20-60	29000	21600	60x91¾	66.14	82¼	85⅜	74¼	81⅛	181⅝	60	3-6	26

*Commercial Ratings, as given, are derived from tests made in accordance with the AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS' Low-Pressure Boiler Code.

★Page Safe Ratings are conservatively made, derived from careful and exhaustive tests, during years of service under every condition—which proved their safety—and are guaranteed, based on fuel of 12,500 B.t.u., with chimney flue of proportions to provide sufficient draft to properly burn the fuel.

PROX
ON THE BANKS OF THE WABASH — SINCE 1853
FRANK PROX COMPANY
TERRE HAUTE - INDIANA.

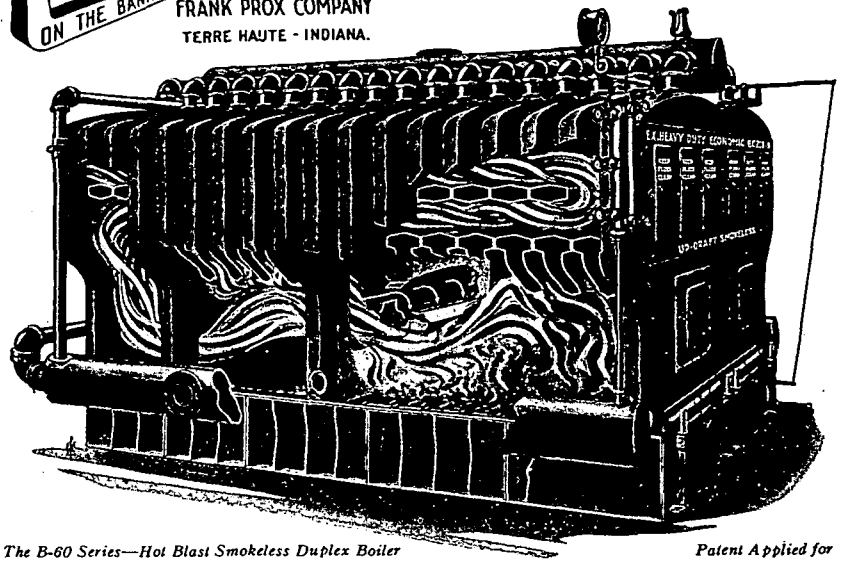
HOT BLAST SMOKELESS

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 waterline, 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

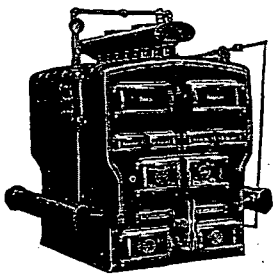
Pierce, Butler & Pierce Mfg. Corp.

General Sales Offices
41 EAST 42nd STREET NEW YORK, N. Y.

For List of Factories and Branches, see Page 549

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

The Pierce-American Boiler



A 30-year record of proved successful performance

Sizes and Dimensions

No.*	Sections	Length	BOILER AND HEADERS Width	BOILER AND HEADERS Height	Height Water Line on S. B.	No. and Size, Outlets	No. and Size, Returns	Smoke Pipe Dia.	Size of Flue	Chimney Height	CAPACITY SQ. FT. Steam Boilers	CAPACITY SQ. FT. Water Boilers
214	4	47	45	56⅛	40¼	2-3	2-3	9½	10x10	30	600	1000
215	5	55	45	56⅛	40¼	2-3	2-3	9½	10x10	30	800	1325
216	6	63	45	56⅛	40¼	2-3	2-3	9½	10x10	35	1000	1650
265	5	55	51	64½	47⅞	2-3	2-3	11¾	12x12	35	1400	2325
266	6	63	51	64½	47⅞	2-4	2-4	11¾	12x16	35	1750	2900
267	7	71	51	64½	47⅞	2-4	2-4	11¾	12x16	40	2100	3475
268	8	79	51	64½	47⅞	2-4	2-4	11¾	16x16	40	2450	4050
325	5	55	59¼	67	49	2-4	2-4	14	12x16	35	1700	2825
326	6	63	59¼	67	49	2-5	2-5	14	12x16	40	2250	3700
327	7	71	59¼	67	49	2-5	2-5	14	16x16	40	2800	4625
328	8	79	59¼	67	49	2-5	2-5	14	16x16	45	3350	5525
329	9	87	59¼	67	49	2-5	2-5	14	16x20	50	3900	6450
3210	10	95	59¼	67	49	2-5	2-5	14	20x20	60	4450	7350
405	5	55	66½	69¼	51	2-4	2-4	15¾	16x16	45	2600	4300
406	6	63	66½	69¼	51	2-5	2-5	15¾	16x20	45	3250	5375
407	7	71	66½	69¼	51	2-5	2-5	15¾	16x20	50	3900	6450
408	8	79	66½	69¼	51	2-5	2-5	15¾	20x20	50	4550	7500
409	9	87	66½	69¼	51	2-5	2-5	15¾	20x20	55	5200	8600
4010	10	95	66½	69¼	51	2-5	2-5	15¾	20x20	55	5850	9650
4011	11	103	66½	69¼	51	2-5	2-5	15¼	20x20	60	6500	10725
4012	12	111	66½	69¼	51	2-5	2-5	15¼	20x24	60	7150	11800
466	6	68	79	82	55¾	2-6	2-6	19¾	24x24	65	5400	8925
467	7	76	79	82	55¾	2-6	2-6	19¾	24x24	70	6500	10725
468	8	84	79	82	55¾	2-6	2-6	19¾	24x24	75	7600	12550
469	9	92	79	82	55¾	2-6	2-6	19¾	24x28	80	8700	14350
4610	10	100	79	82	55¾	2-6	2-6	19¾	24x28	85	9800	16150
4611	11	108	79	82	55¾	2-6	2-6	19¾	28x28	95	10900	18000
4612	12	116	79	82	55¾	2-6	2-6	19¾	28x28	100	12000	19825
4613	13	124	79	82	55¾	2-6	2-6	19¾	28x28	105	13100	21625
4614	14	132	79	82	55¼	2-6	2-6	19¼	28x32	110	14200	23450

*Steam boilers are designated by the letter "S" before the number, as S-214, S-215, etc. Water boilers are designated by the letter "W," as W-214, W-215, etc.

All measurements are in inches, except where otherwise noted. Special sizes or location of tappings can be furnished at prices shown in discount sheet. Blank grates sections for brick fire wall to reduce size of grate will be supplied without extra charge with boiler if so ordered.

(See page 549, Valve Section)

PIERCE FIREBOX BOILERS

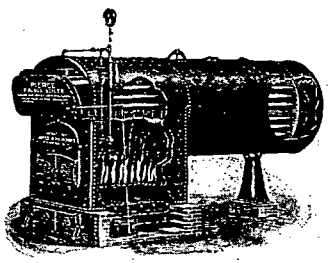
Built by

Ames Iron Works

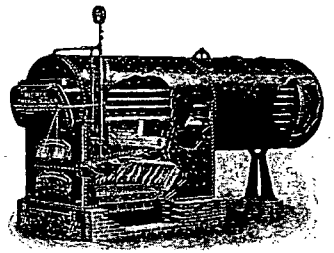
Division of

Pierce, Butler & Pierce Manufacturing Corporation

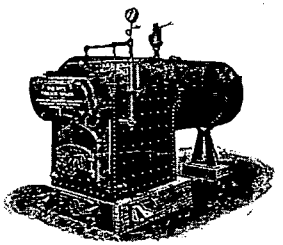
OSWEGO, N. Y.



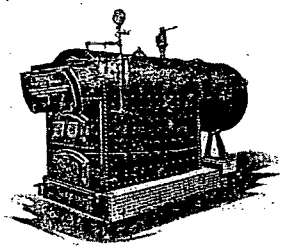
Series 600
For Description, see p. 356.



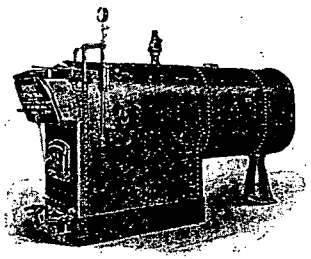
Series 700
For Description, see p. 357.



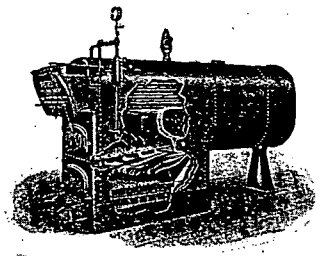
Series 800
For Description, see p. 358.



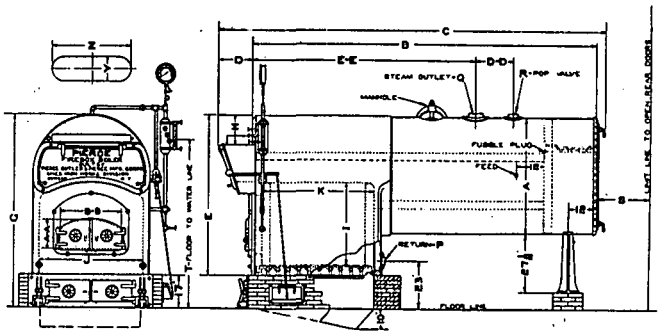
Series 900
For Description, see p. 359.

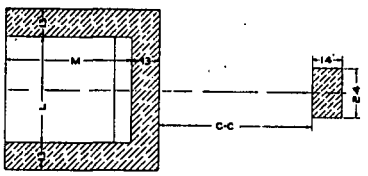


Series 1000
For Description, see p. 360.



Series 2000
For Description, see p. 361.

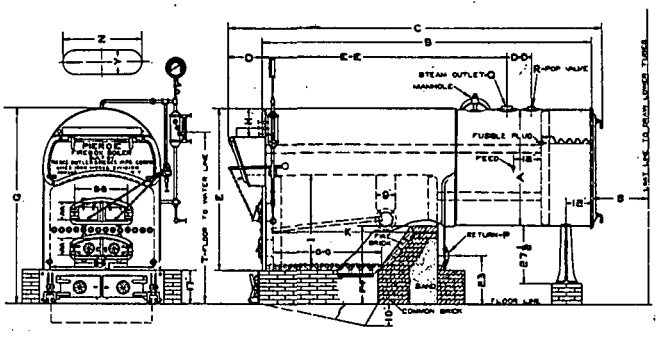


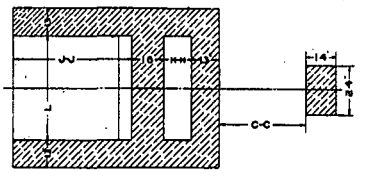


Data and Setting Dimensions—
PIERCE FIREBOX BOILER
with Plain Furnace—Series 600

NUMBER OF SIZE		613	614	615	616	617	618	619	620	621	622	623	624
Code Word		Kail	Kate	Keel	Kelp	Khan	Kill	King	Knee	Knot	Kohl	Kroo	Kurd
Capacity Steam Radiation	Sq. Ft.	5500	6000	7000	8000	9500	11000	13000	15000	17500	20000	25000	28000
Capacity Water Radiation	Sq. Ft.	8250	9000	10500	12000	15250	16500	19500	22500	26250	30000	37500	42000
Grate Area	Sq. Ft.	19.5	20.6	20.6	22.9	25.5	28.0	30.8	33.5	36.6	39.6	42.9	46.1
Heating Surface	Sq. Ft.	572	736	676	778	929	1040	1168	1303	1514	1711	2209	2427
*Diameter Breeching	In.	28	28	28	28	32	32	34	34	36	36	42	42
*Diameter Smoke Stack	In.	26	26	26	26	30	30	32	32	34	34	40	40
*Minimum Length Smoke Stack	Ft.	60	60	65	65	65	70	70	70	80	90	90	100
Weight Boiler without Fixtures	Lbs.	13300	14300	14500	15500	19200	20300	20200	23900	27300	29300	35800	39800
Weight Boiler Complete	Lbs.	15100	16200	16400	17600	21500	22700	23000	26800	30500	32700	39500	43700
A Diameter Shell	In.	60	60	60	60	66	66	72	72	78	78	84	84
B Length Shell		12′ 5″	13′ 7″	14′ 4″	16′ 2″	15′ 9″	17′ 4″	15′ 11″	17′ 6″	17′ 11″	19′ 11″	20′ 1″	22′ 1″
C Length Over All		14′ 4½″	15′ 6½″	16′ 3½″	18′ 1½″	17′ 11″	19′ 6″	18′ 3″	19′ 10″	20′ 3″	22′ 3″	22′ 8″	24′ 8″
D Depth Smoke Box Over All	In.	20	20	20	20	22½	22½	24½	24½	24½	24½	27½	27½
G Floor Line to Top Shell	In.	101	101	101	101	107	107	113	113	115	115	121	121
H Top Smoke Box to Top Shell	In.	15	15	15	15	16	16	17½	17½	17½	17½	16	16
I Height Furnace above Grates	In.	43	43	43	43	46	46	48½	48½	49	49	52	52
J Width Furnace	In.	53	53	53	53	59	59	65	65	71	71	77	77
K Length Furnace	In.	53	56	56	62	62	68	68	74	74	80	80	86
L Width Ash Pit	In.	53	53	53	53	59	59	65	65	71	71	77	77
M Length Ash Pit	In.	57	60	60	66	66	72	72	78	78	84	84	90
†P Size Return	In.	5	5	5	5	6	6	6	6	6	6	6	6
†Q Size Steam Outlet	In.	7	7	7	7	8	8	8	8	8	8	10	10
†R No. and Size Pop Valves	In.	3	3	3	3	3½	3½	4	4	4½	2-3	2-3	2-3
S Required to Open Rear Doors	In.	32	32	32	32	35	35	38	38	41	41	44	44
T Height Water Line	In.	87	87	87	87	99	90	96	96	97	97	105	105
Y Width Stack Base	In.	12½	12½	12½	12½	15	15	17	17	17	17	20	20
Z Length Stack Base	In.	46	46	46	46	50	50	54	54	60	60	64	64
CC Location Rear Pier		5′ 1″	6′ 0″	6′ 9″	8′ 1″	7′ 8″	8′ 9″	7′ 4″	8′ 5″	8′ 10″	10′ 4″	10′ 6″	12′ 0″
DD Location Pop Valve	In.	16	18	21	27	18	30	18	24	24	30	24	21
EE Location Steam Outlet		8′ 3″	8′ 8″	8′ 5″	9′ 5″	9′ 4″	10′ 2″	9′ 8″	11′ 1″	11′ 3″	12′ 0″	12′ 6″	12′ 6″
Number Common Brick		665	680	680	710	740	760	790	820	840	885	900	935
Out Surface to be Covered	Sq. Ft.	190	220	250	280	290	310	315	345	385	425	455	505

Safety valves will be furnished to conform to the requirements of the state or municipality in which boiler is to be operated. *Smoke stacks and smoke connections or breechings are not furnished unless specially ordered and at extra price. †Size and location of all steam openings shown apply for 15 pounds pressure. This information will be given for higher pressures upon request.

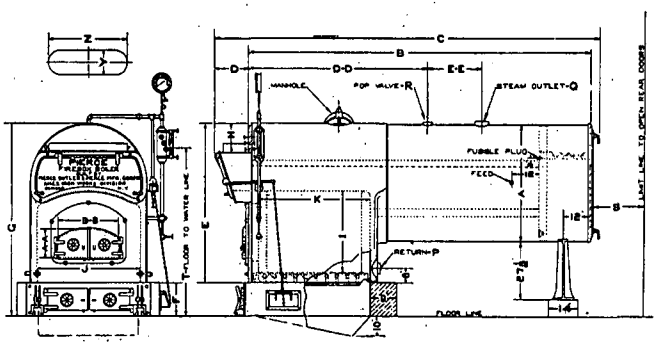


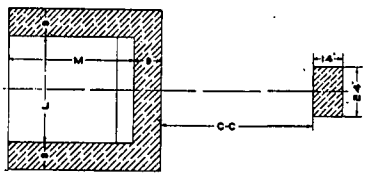


Data and Setting Dimensions—
PIERCE FIREBOX BOILER
with Downdraft Furnace—Series 700

NUMBER OF SIZE		713	714	715	716	717	718	719	720	721	722	723	724
Code Word		Kairo	Karat	Kayak	Kazoo	Kedge	Ketch	Kiddy	Klang	Knack	Knell	Koran	Kraal
Capacity Steam Radiation	Sq. Ft.	6000	6500	7500	8500	10000	12000	14000	16000	18000	20000	25000	30000
Capacity Water Radiation	Sq. Ft.	9000	9750	11250	12750	15000	18000	21000	24000	27000	30000	37500	45000
Area Upper Grate	Sq. Ft.	17.7	19.3	20.0	21.4	23.5	25.9	28.5	29.9	32.6	34.6	41.7	44.8
Heating Surface	Sq. Ft.	601	652	721	773	912	1053	1204	1316	1458	1549	2074	2629
*Diameter Breeching	In.	28	28	28	28	32	32	34	34	36	36	42	42
*Diameter Smoke Stack	In.	26	26	26	26	30	30	32	32	34	34	40	40
*Minimum Length Smoke Stack	Ft.	60	60	65	65	65	70	70	70	80	90	90	100
Weight Boiler without Fixtures	Lbs.	14500	15200	16200	16900	19700	21300	23300	24800	28000	29200	38500	42100
Weight Boiler Complete	Lbs.	16300	17100	18200	19100	21900	23700	26000	27700	31100	32300	42100	45900
A Diameter Shell	In.	60	60	60	60	66	66	72	72	78	78	84	84
B Length Shell		12′ 11″	13′ 11″	15′ 3″	16′ 3″	15′ 9″	17′ 9″	16′ 7″	18′ 0″	17′ 10″	18′ 10″	20′ 1″	24′ 1″
C Length Over All		14′ 10½″	15′ 10½″	17′ 2½″	18′ 2½″	17′ 11″	19′ 11″	18′ 11″	20′ 4″	20′ 2″	21′ 2″	22′ 8″	26′ 8″
D Depth Smoke Box Over All	In.	20	20	20	20	22½	22½	24½	24½	24½	24½	27½	27½
G Floor Line to Top Shell	In.	101	101	101	101	107	107	113	113	115	115	121	121
H Top Smoke Box to Top Shell	In.	15	15	15	15	16	16	17½	17½	17½	17½	16	16
J Width Furnace	In.	53	53	53	53	59	59	65	65	71	71	77	77
K Length Furnace	In.	75	81	90	96	90	96	96	102	102	108	114	120
L Width Ash Pit	In.	53	53	53	53	59	59	65	65	71	71	77	77
†P Size Return	In.	5	5	5	5	6	6	6	6	6	6	6	6
†Q Size Steam Outlet	In.	7	7	7	7	8	8	8	8	8	8	10	10
†R No. and Size Pop Valves	In.	3	3½	3½	4	4	4	4½	2-3	2-3	2-3	2-3½	2-3½
S Required to Draw Lower Tubes	In.	34	40	49	55	51	69	51	62	60	66	75	117
T Height Water Line	In.	87	87	87	87	90	90	96	96	97	97	105	105
Y Width Stack Base	In.	12½	12½	12½	12½	15	15	17	17	17	17	20	20
Z Length Stack Base	In.	46	46	46	46	50	50	54	54	60	60	64	64
CC Location Rear Pier	In.	40	46	58	64	64	82	68	79	77	83	92	134
DD Location Pop Valve	In.	14	18	16	18	16	18	15	18	15	16	18	20
EE Location Steam Outlet		9′ 9″	10′ 3″	10′ 11″	11′ 6″	11′ 0″	11′ 9″	11′ 7″	12′ 2″	12′ 2″	12′ 9″	13′ 8″	15′ 0″
GG Length Lower Grates	In.	52	58	61	67	61	67	67	73	73	73	79	85
HH Width Sand Fill	In.	13	13	13	13	13	13	13	13	13	19	19	19
JJ Location Bridge Wall	In.	53	59	63	69	63	69	69	75	75	75	81	87
Number Common Brick		1160	1210	1300	1350	1300	1350	1375	1450	1400	1475	1575	1600
Number Fire Brick		195	195	210	215	240	240	255	255	290	315	425	425
Out Surface to be Covered	Sq. Ft.	255	265	266	280	290	330	335	360	370	400	455	545

Safety valves will be furnished to conform to the requirements of the state or municipality in which boiler is to be operated. *Smoke stacks and smoke connections or breechings are not furnished unless specially ordered and at extra price. †Size and location of all steam openings shown apply for 15 pounds pressure. This information will be given for higher pressures upon request.

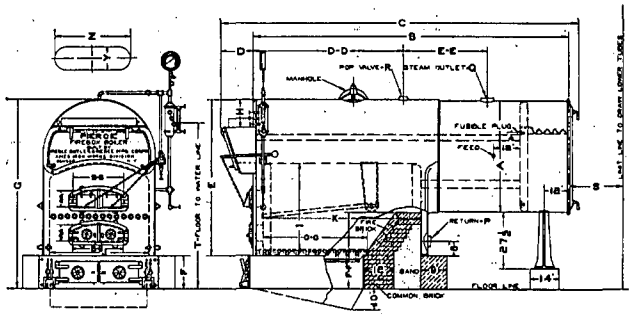


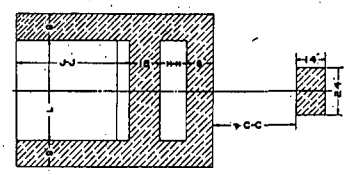


Data and Setting Dimensions—
PIERCE FIREBOX BOILER
with Plain Furnace—Series 800

NUMBER OF SIZE	810	812	813	814	815	816	818	820	823	825	827	830	833	837	840
Code Word	Fagus	Fahan	Faint	Fairy	Faker	Falca	False	Famed	Fancy	Fangl	Fanon	Farce	Fastu	Fatal	Favos
Capacity Steam Radiation....Sq. Ft.	5150	6500	7200	7600	8250	9000	10000	11500	13000	15000	16500	18000	20000	22500	25000
Capacity Water Radiation....Sq. Ft.	7725	9750	10800	11400	12375	13500	15000	17250	19500	22500	24750	27000	30000	33750	37500
Grate Area....Sq. Ft.	16.0	18.0	20.0	22.5	22.5	24.7	24.7	27.5	30.0	30.0	33.0	35.7	36.0	42.0	42.0
Heating Surface....Sq. Ft.	511	613	661	726	763	826	900	1027	1158	1255	1349	1501	1644	1877	2017
*Diameter Breeching....In.	26	26	26	30	30	30	30	34	34	34	36	36	38	38	38
*Diameter Smoke Stack....In.	24	24	24	28	28	28	28	32	32	32	34	34	36	36	36
*Minimum Length Smoke Stack....Ft.	60	75	80	60	65	75	85	70	80	90	80	90	85	105	115
Weight Boiler without Fixtures....Lbs.	9270	10400	11160	11910	12130	12970	13670	16560	17940	19060	20840	22060	24520	26980	28890
Weight Boiler Complete....Lbs.	10980	12320	13170	14120	14340	15340	16040	19190	20750	21860	23920	25340	27840	30730	32640
A Diameter Shell....In.	54	54	54	60	60	60	60	66	66	66	72	72	78	78	78
B Length Shell	11′ 9″	13′ 9″	14′ 9″	13′ 0″	13′ 6″	14′ 6″	15′ 6″	14′ 0″	15′ 6″	16′ 6″	15′ 6″	17′ 0″	15′ 6″	17′ 6″	18′ 6″
C Length Over All	13′ 6″	15′ 6″	16′ 6″	14′ 11″	15′ 5″	16′ 5″	17′ 5″	16′ 2″	17′ 8″	18′ 8″	17′ 8″	19′ 2″	18′ 0″	20′ 0″	21′ 0″
D Depth Smoke Box Over All....In.	18	18	18	20	20	20	20	23	23	23	23	23	27	27	27
F Height Ash Pit....In.	14	14	14	14	14	14	14	14	14	14	18	18	18	18	18
G Floor Line to Top Shell....In.	89	89	89	95	95	95	95	101	101	101	111	111	119	119	119
H Top Smoke Box to Top Shell....In.	13½	13½	13½	12¾	12¾	12¾	12¼	15¾	15¾	15¾	18½	18½	16	16	16
I Height Furnace Above Grates....In.	40	40	40	43	43	43	43	46	46	46	49	49	55	55	55
J Width Furnace....In.	48	48	48	54	54	54	54	60	60	60	66	66	72	72	72
K Length Furnace....In.	48	54	60	60	60	66	66	66	72	72	72	78	72	84	84
L Width Ash Pit....In.	48	48	48	54	54	54	54	60	60	60	66	66	72	72	72
M Length Ash Pit....In.	52	58	64	64	64	70	70	70	76	76	76	82	76	88	88
†P Size Return....In.	4	4	4	6	6	6	6	6	6	6	6	6	6	6	6
†Q Size Steam Outlet....In.	6	6	6	8	8	8	8	8	8	8	8	8	10	10	10
†R Number and Size Pop Valves	2½	2½	3	3	3	3½	3½	3½	4	4	4	4½	4½	2-3	2-3
S Required to Open Rear Doors....In.	31	31	31	34	34	34	34	37	37	37	40	40	43	43	43
T Height Water Line....In.	76	76	76	83	83	83	83	86	86	86	93	93	103	103	103
Y Width Stack Base....In.	12	12	12	14	14	14	14	17	17	17	17	17	20	20	20
Z Length Stack Base....In.	41	41	41	47	47	47	47	51	51	51	57	57	56	56	56
CC Location Rear Pier....In.	65	83	89	66	72	78	90	72	84	96	84	96	84	96	108
DD Location Pop Valve....In.	36	36	36	36	36	36	42	42	42	42	50	50	50	50	50
EE Location Steam Outlet....In.	24	30	30	30	30	36	36	30	36	40	45	48	48	48	48
Number Common Brick	345	370	395	405	405	425	425	435	455	455	605	635	625	680	680
Out Surface to be Covered...Sq. Ft.	200	225	240	240	250	265	280	280	305	325	335	365	365	410	430

Safety valves will be furnished to conform to the requirements of the state or municipality in which boiler is to be operated. *Smoke stacks and smoke connections or breechings are not furnished unless specially ordered and at extra price. †Size and location of all steam openings shown apply for 15 pounds pressure. This information will be given for higher pressures upon request.

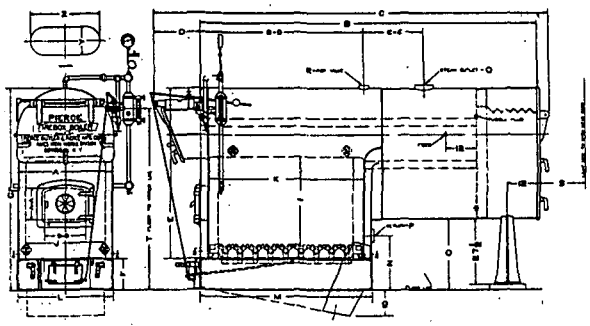


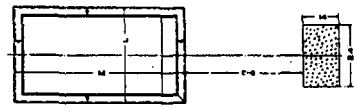


Data and Setting Dimensions—
PIERCE FIREBOX BOILER
with Downdraft Furnace—Series 900

NUMBER OF SIZE	910	912	913	914	915	916	918	920	923	925	927	930	933	937
Code Word	Fehme	Felid	Felon	Feluc	Femur	Fence	Fenks	Feoff	Ferny	Fervu	Feuda	Fever	Fewel	Feyre
Capacity Steam Radiation....Sq. Ft.	5200	6100	6500	7500	8200	9000	10250	12000	13500	15250	16000	18000	20000	23500
Capacity Water Radiation....Sq. Ft.	7800	9150	9750	11250	12300	13500	15375	18000	20250	22875	24000	27000	30000	35250
Area Upper Grate....Sq. Ft.	15.8	17.8	19.7	22.2	22.2	24.5	24.5	26.7	29.6	32.1	34.6	35.3	35.3	39.9
Heating Surface....Sq. Ft.	517	597	622	718	765	831	901	1009	1154	1286	1330	1500	1662	1810
*Diameter Breeching....In.	26	26	26	30	30	30	30	30	34	34	34	36	36	36
*Diameter Smoke Stack....In.	24	24	24	28	28	28	28	32	32	32	32	34	34	34
*Minimum Length Smoke Stack....Ft.	60	75	80	60	65	75	85	95	80	90	100	90	100	110
Weight Boiler without Fixtures....Lbs.	10290	11300	11850	13260	13660	14760	15370	16670	20180	21480	22790	24000	24470	26550
Weight Boiler Complete....Lbs.	12010	13170	13870	15480	15880	17160	17770	19230	23040	24300	26000	27300	27740	30230
A Diameter Shell....In.	54	54	54	60	60	60	60	60	66	66	66	72	72	72
B Length Shell	11′ 9″	13′ 3″	13′ 9″	12′ 10″	13′ 6″	14′ 6″	15′ 6″	17′ 0″	15′ 6″	17′ 0″	17′ 6″	17′ 0″	18′ 6″	20′ 0″
C Length Over All	13′ 6″	15′ 0″	15′ 6″	14′ 9″	15′ 5″	16′ 5″	17′ 5″	18′ 11″	17′ 8″	19′ 2″	19′ 8″	19′ 9″	20′ 8″	22′ 2″
D Depth Smoke Box Over All....In.	18	18	18	20	20	20	20	20	23	23	23	23	23	23
F Height Ash Pit....In.	14	14	14	14	14	14	14	14	14	14	14	18	18	18
G Floor Line to Top Shell....In.	92	92	92	98	98	98	98	98	104	104	104	114	114	114
H Top Smoke Box to Top Shell....In.	13½	13½	13½	12¼	12¾	12¾	12¾	12¾	15¾	15¾	15¾	18½	18½	18½
J Width Furnace....In.	48	48	48	54	54	54	54	54	60	60	60	66	66	66
K Length Furnace....In.	74	78	84	84	85	90	92	96	97	104	108	102	104	114
L Width Ash Pit....In.	48	48	48	54	54	54	54	54	60	60	60	66	66	66
†P Size Return....In.	4	4	4	6	6	6	6	6	6	6	6	6	6	6
†Q Size Steam Outlet....In.	6	6	6	8	8	8	8	8	8	8	8	10	10	10
†R Number and Size Pop Valves	3	3	3½	3½	3½	4	4	4	4½	2-3	2-3	2-3	2-3	2-3½
S Required to Draw Lower Tubes....In.	24	38	38	21	28	35	45	59	40	51	53	53	69	77
T Height Water Line....In.	79	79	79	86	86	86	86	86	89	89	89	96	96	96
Y Width Stack Base....In.	12	12	12	14	14	14	14	14	17	17	17	17	17	17
Z Length Stack Base....In.	41	41	41	47	47	47	47	47	51	51	51	57	57	57
CC Location Rear Pier....In.	40	54	54	41	48	55	65	79	60	71	73	73	89	97
DD Location Pop Valve....In.	24	24	24	24	24	48	48	48	48	48	48	48	48	48
EE Location Steam Outlet....In.	30	36	36	30	36	36	36	48	36	36	36	36	48	48
GG Length Lower Grates....In.	48	54	60	60	60	66	66	72	72	78	84	78	78	88
HH Width Sand Fill....In.	14	12	12	12	13	12	14	12	13	14	12	12	14	14
JJ Location Bridge Wall....In.	51	57	63	63	63	69	69	75	75	81	87	81	81	91
Number Common Brick	690	715	740	785	790	810	815	835	880	910	930	1155	1165	1215
Number Fire Brick	80	80	80	90	90	90	90	90	110	110	110	120	120	120
Out Surface to be Covered....Sq. Ft.	215	230	250	245	255	270	285	310	315	340	350	370	400	430

Safety valves will be furnished to conform to the requirements of the state or municipality in which boiler is to be operated. *Smoke stacks and smoke connections or breechings are not furnished unless specially ordered and at extra price. †Size and location of all steam openings shown apply for 15 pounds pressure. This information will be given for higher pressures upon request.

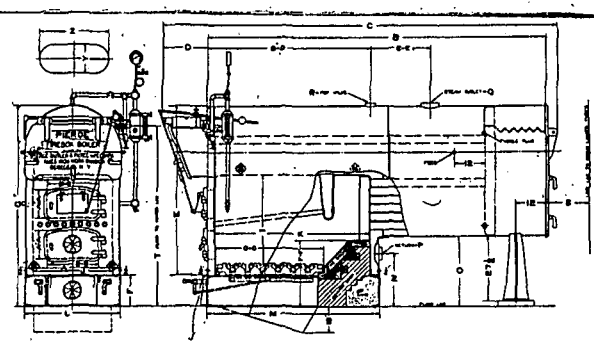


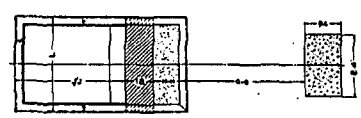


Data and Setting Dimensions—
PIERCE FIREBOX BOILER
with Plain Furnace—Series 1000

NUMBER OF SIZE	1022	1027	1033	1040	1046	1052	1058	1065	1070	1075	1085	1095	1110	1120	1130
Code Word	Aard	Abba	Aces	Adam	Aeon	Afar	Aged	Airy	Alas	Amic	Anet	Apod	Arab	Asse	Atom
Capacity Steam Radiation...Sq. Ft.	2250	2750	3300	4000	4600	5200	5800	6500	7000	7500	8500	9500	11000	12000	13000
Capacity Water Radiation...Sq. Ft.	3375	4125	4950	6000	6900	7800	8700	9750	10500	11250	12750	14250	16500	18000	19500
Grate Area...Sq. Ft.	7.3	9.4	10.4	12.9	14.2	15.5	16.5	18.0	19.5	21.0	21.0	22.8	24.5	28.0	28.0
Heating Surface...Sq. Ft.	230	280	335	386	446	499	556	604	657	699	782	888	994	1093	1181
*Diameter Smoke Stack...In.	18	18	18	22	22	22	24	24	24	24	26	26	26	30	30
*Minimum Length Smoke Stack...Ft.	50	70	85	55	70	85	60	70	80	90	85	95	105	85	105
Weight Boiler without Fixtures...Lbs.	5800	5900	6000	7500	7700	8000	9300	9500	9700	9900	12300	12700	13200	15100	15700
Weight Boiler Complete...Lbs.	7100	7300	7500	9300	9600	9900	11300	11600	12000	12300	15000	15600	16300	18400	19000
A Width Shell...In.	30	30	30	36	36	36	42	42	42	42	48	48	48	54	54
B Length Shell...	8' 6"	10' 0"	11' 6"	11' 0"	12' 4"	13' 6"	11' 6"	12' 4"	13' 3"	14' 0"	12' 0"	13' 3"	14' 6"	14' 0"	14' 9"
C Length Over All...	10' 4"	11' 10"	13' 4"	13' 1"	14' 5"	15' 7"	13' 7"	14' 5"	15' 4"	16' 1"	14' 1"	15' 4"	16' 7"	16' 4"	17' 1"
D Depth Smoke Box Over All...In.	18	18	18	21	21	21	21	21	21	21	21	21	21	24	24
E Height Boiler Only...In.	61⅝	61⅝	61⅝	65⅝	65⅝	65⅝	75¼	75¼	75¼	75¼	82¼	82¼	82¼	86⅝	86⅝
F Height Channel Base...In.	12	12	12	12	12	12	12	12	12	12	15	15	15	15	15
G Floor Line to Top Shell...In.	73⅝	73⅝	73⅝	77⅛	77⅛	77⅛	87¼	87¼	87¼	87¼	97¾	97¾	97¾	101⅝	101⅝
H Top Smoke Box to Top Shell...In.	9¼	9¼	9¼	8¼	8¼	8¼	11	11	11	11	12½	12½	12½	14¼	14¼
I Height Furnace above Grates...In.	30	30	30	33	33	33	36	36	36	36	38	38	38	40	40
J Width Furnace...In.	25	25	25	31	31	31	36	36	36	36	42	42	42	48	48
K Length Furnace...In.	42	54	60	60	66	72	66	72	78	84	72	78	84	84	84
L Width Channel Base...In.	31⅛	31⅛	31⅛	37⅛	37⅛	37⅛	43⅛	43⅛	43⅛	43⅛	49⅛	49⅛	49⅛	55⅛	55⅛
M Length Channel Base...In.	48¼	60¼	66¼	66¼	72¼	78¼	74¼	80¼	86¼	92¼	80¼	86¼	92¼	92¼	92¼
N Location Return...In.	20½	20½	20½	20¾	20¾	20¾	21	21	21	21	21⅞	21⅞	21⅞	22⅜	22⅜
O Floor Line to Bottom Shell...In.	27½	27½	27½	27⅝	27⅝	27⅝	30⅛	30⅛	30⅛	30⅛	29¼	29¼	29¼	31¾	31¾
P Size Return...In.	3	3	3	4	4	4	4	4	4	4	5	5	5	6	6
Q Size Steam Outlet...In.	5	5	5	6	6	6	6	6	6	6	7	7	7	8	8
R Size Pop Valve...In.	1½	2	2	2	2½	2½	2½	2½	3	3	3	3	3½	3½	3½
S Required to Open Rear Doors...In.	40	40	40	42	42	42	25	25	25	25	28	28	28	31	31
T Height Water Line...In.	64⅝	64⅝	64⅝	69⅝	69⅝	69⅝	76½	76½	76½	76½	85½	85½	85½	87⅞	87⅞
Y Width Stack Base...In.	13	13	13	16	16	16	16	16	16	16	15	15	15	19	19
Z Length Stack Base...In.	22	22	22	27	27	27	32	32	32	32	37	37	37	42	42
AA Height Fire Door Opening...In.	12	12	12	12	12	12	14	14	14	14	13	13	13	14	14
BB Width Fire Door Opening...In.	16	16	16	20	20	20	24	24	24	24	28	28	28	34	34
CC Location Rear Pier...In.	33¾	39¾	51¾	45¾	55¾	63¾	44¼	48¼	53¼	56¼	44¼	53¼	62¼	56¼	65¼
DD Location Pop Valve...In.	43	55	61	61	67	73	68	74	80	86	74	80	86	86	86
EE Location Steam Outlet...In.	22	24	32	26	34	36	26	30	32	34	26	32	36	48	48
Out Surface to be Covered...Sq. Ft.	96	116	132	140	156	169	169	181	193	211	199	219	239	246	264

BOILERS BUILT FOR 15 POUNDS PRESSURE ONLY. Safety valves will be furnished to conform to the requirements of the state or municipality in which boiler is to be operated.
*Smoke stacks and smoke connections or breechings are not furnished unless specially ordered and at extra price.





Data and Setting Dimensions—
PIERCE FIREBOX BOILER
with Downdraft Furnace—Series 2000

NUMBER OF SIZE	2022	2027	2033	2040	2046	2052	2058	2065	2070	2075	2085	2095	2110	2120	2130
Code Word	Abhor	Acorn	Adder	Afoot	Aglee	Alban	Amber	Ankle	Apoda	Ardor	Aster	Atone	Auger	Avale	Awing
Capacity Steam Radiation...Sq. Ft.	2250	2750	3300	4000	4600	5200	5800	6500	7000	7500	8500	9500	11000	12000	13000
Capacity Water Radiation...Sq. Ft.	3375	4125	4950	6000	6900	7800	8700	9750	10500	11250	12750	14250	16500	18000	19500
Area Upper Grate...Sq. Ft.	4.6	6.6	7.6	8.9	10.1	11.4	11.8	13.3	14.7	16.2	15.5	17.2	19.0	21.7	21.7
Heating Surface...Sq. Ft.	230	280	335	386	446	499	556	604	657	699	782	888	994	1093	1181
*Diameter Smoke Stack...In.	18	18	18	22	22	22	24	24	24	24	26	26	26	30	24
*Minimum Length Smoke Stack...Ft.	50	70	85	55	70	85	60	70	80	90	85	95	105	85	105
Weight Boiler without Fixtures...Lbs.	5800	5900	6000	7500	7700	8000	9300	9500	9700	9900	12300	12700	13200	15100	15700
Weight Boiler Complete...Lbs.	7100	7300	7500	9300	9600	9900	11300	11600	12000	12300	15000	15600	16300	18400	19000
A Width Shell...In.	30	30	30	36	36	36	42	42	42	42	48	48	48	54	54
B Length Shell...	8' 6"	10' 0"	11' 6"	11' 0"	12' 4"	13' 6"	11' 6"	12' 4"	13' 3"	14' 0"	12' 0"	13' 3"	14' 6"	14' 0"	14' 9"
C Length Over All...	10' 4"	11' 10"	13' 4"	13' 1"	14' 5"	15' 7"	13' 7"	14' 5"	15' 4"	16' 1"	14' 1"	15' 4"	16' 7"	16' 4"	17' 1"
D Depth Smoke Box Over All...In.	18	18	18	21	21	21	21	21	21	21	21	21	21	24	24
E Height Boiler Only...In.	61⅝	61⅝	61⅝	65⅝	65⅝	65⅝	75¼	75¼	75¼	75¼	82¼	82¼	82¼	86⅝	86⅝
F Height Channel Base...In.	12	12	12	12	12	12	12	12	12	12	15	15	15	15	15
G Floor Line to Top Shell...In.	73⅝	73⅝	73⅝	77⅛	77⅛	77⅛	87¼	87¼	87¼	87¼	97¾	97¾	97¾	101⅝	101⅝
H Top Smoke Box to Top Shell...In.	9¼	9¼	9¼	8¼	8¼	8¼	11	11	11	11	12½	12½	12½	14¼	14¼
I Hght. Furn. above Lower Grates...In.	30	30	30	33	33	33	36	36	36	36	38	38	38	40	40
J Width Furnace...In.	25	25	25	31	31	31	36	36	36	36	42	42	42	48	48
K Length Furnace...In.	42	54	60	60	66	72	66	72	78	84	72	78	84	84	84
L Width Channel Base...In.	31⅛	31⅛	31⅛	37⅛	37⅛	37⅛	43⅛	43⅛	43⅛	43⅛	49⅛	49⅛	49⅛	55⅛	55⅛
M Length Channel Base...In.	48¾	60¼	66¾	66¾	72¼	78¾	74¼	80¼	86¼	92¼	80¼	86¼	92¼	92¼	92¼
N Location Return...In.	20½	20½	20½	20¾	20¾	20¾	21	21	21	21	21⅞	21⅞	21⅞	22⅜	22⅜
O Floor Line to Bottom Shell...In.	27½	27½	27½	27⅝	27⅝	27⅝	30⅛	30⅛	30⅛	30⅛	29¼	29¼	29¼	31¾	31¾
P Size Return...In.	3	3	3	4	4	4	4	4	4	4	5	5	5	6	6
Q Size Steam Outlet...In.	5	5	5	6	6	6	6	6	6	6	7	7	7	8	8
R Size Pop Valve...In.	1¼	1½	2	2	2	2½	2½	2½	2½	3	3	3	3½	3½	3½
S Required to Draw Lower Tubes...In.	40	40	40	42	42	42	25	25	29	32	28	29	38	32	41
T Height Water Line...In.	64⅝	64⅝	64⅝	69⅝	69⅝	69⅝	76½	76½	76½	76½	85½	85½	85½	87⅞	87⅞
Y Width Stack Base...In.	13	13	13	16	16	16	16	16	16	16	15	15	15	19	19
Z Length Stack Base...In.	22	22	22	27	27	27	32	32	32	32	37	37	37	42	42
AA Height Fire Door Openings...In.	11	11	11	11	11	11	11	11	11	11	11¼	11¼	11¼	11¼	11¼
BB Width Fire Door Openings...In.	20	20	20	20	20	20	20	20	20	20	29¼	29¼	29¼	29¼	29¼
CC Location Rear Pier...In.	33¾	39¼	51¾	45¾	55¾	63¾	44¼	48¼	53¼	56¼	44¼	53¼	62¼	56¼	65¼
DD Location Pop Valve...In.	43	55	61	61	67	73	68	74	80	86	74	80	86	86	86
EE Location Steam Outlet...In.	22	24	32	26	34	36	26	30	32	34	26	32	36	48	48
FF Height Bridge Wall...In.	28	28	28	28	28	28	30	30	30	30	29	29	29	35	35
GG Length Lower Grates...In.	30	42	48	42	48	54	48	54	60	66	54	60	66	66	66
HH Width Sand Fill...In.	5	5	5	11	11	11	12	12	12	12	12	12	12	12	12
JJ Location Bridge Wall...In.	31½	43½	49½	43½	49½	55½	50	56	62	68	56	62	68	68	68
Out Surface to be Covered...Sq. Ft.	96	116	132	140	156	169	169	181	193	211	199	219	239	246	264

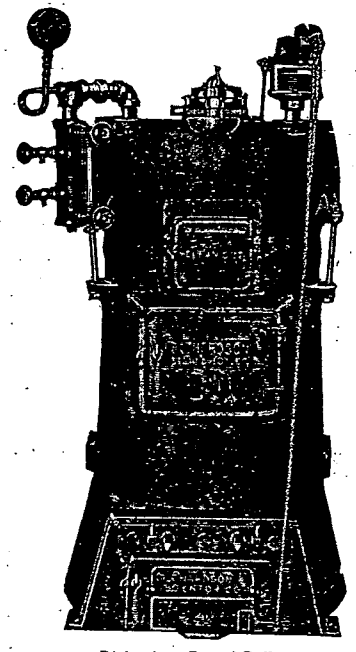
BOILERS BUILT FOR 15 POUNDS PRESSURE ONLY. Safety valves will be furnished to conform to the requirements of the state or municipality in which boiler is to be operated.
*Smoke stacks and smoke connections or breeching are not furnished unless specially ordered and at extra price.

Richardson & Boynton Co.

Manufacturers of
"RICHARDSON" "PERFECT"
Heating and Cooking Apparatus Since 1837

Executive Offices:
260 Fifth Avenue, NEW YORK CITY

CHICAGO	BOSTON	CLEVELAND	MINNEAPOLIS
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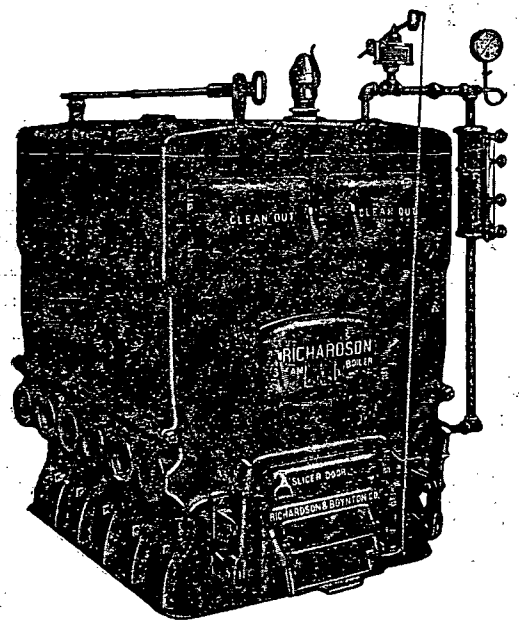
Richardson Round Boiler

RICHARDSON ROUND BOILERS
Ratings and Dimensions

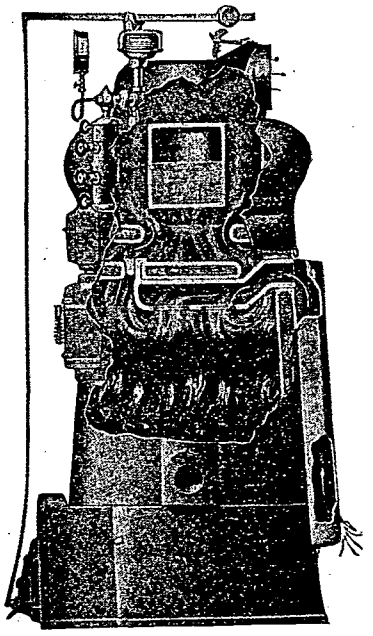
Boiler No.	8-Hour Rating Sq. Ft. Steam	8-Hour Rating Sq. Ft. Water	Nom. Diam. Grate In.	Grate Area Sq. Ft.	Height to Top Outlet, In.* Steam	Height to Top Outlet, In.* Water	Height Water Line In.	Outlets and Inlets No. and Size	Direct Rad. Boiler will Supply Sq. Ft.
1190	300	500	19	1.97	47½	45¼	42½	2-2½	200
1191	350	575	19	1.97	51½	49¼	46½	2-2½	235
1192	375	625	19	1.97	55½	53¼	50½	2-2½	250
1221	450	750	22	2.64	53	50½	48¼	2-2½	300
1222	500	825	22	2.64	57	54½	52¼	2-2½	335
1223	550	900	22	2.64	61	58½	56¼	2-2½	375
1251	625	1025	25	3.41	54½	52	49½	2-3	410
1252	675	1100	25	3.41	58¼	56	53½	2-3	450
1253	725	1200	25	3.41	62¼	60	57¼	2-3	480
1281	875	1350	28	4.28	55¾	53¼	51	2-3½	600
1282	950	1550	28	4.28	59¾	57¼	55	2-3½	650
1283	1025	1675	28	4.28	63¾	61¼	59	2-3½	700

RICHARDSON SECTIONAL BOILER
Ratings and Dimensions

Boiler Number	8-Hr. Rating Sq. Ft. Steam	8-Hr. Rating Sq. Ft. Water	Grate Area, Sq. Ft.	Height to Top Outlet, In.	Height Water-line, In.	Ashpit, Inside, In.	No. Outlets and Size, In.
255C	1000	1600	4.57	55	48¼	27½x35½	2-3½
256C	1250	2000	5.70	55	48¼	27½x42¾	2-3½
257C	1500	2400	6.83	55	48¼	27½x50	2-3½
258C	1700	2800	7.97	55	48¼	27½x57¼	2-3½
355C	1950	3125	7.85	63	56	39 x33¼	2-4
356C	2400	3850	9.81	63	56	39 x41½	2-4
357C	2850	4575	11.75	63	56	39 x50	3-4
358C	3300	5300	13.70	63	56	39 x58¼	3-4
359C	3750	6025	15.65	63	56	39 x66½	3-4
427C	3500	5600	13.82	66	60	45 x50	2-5
428C	4050	6500	16.11	66	60	45 x58¼	2-5
429C	4600	7400	18.40	66	60	45 x66½	2-5
4210C	5150	8300	20.69	66	60	45 x74¾	3-5
4211C	5700	9200	22.98	66	60	45 x83	3-5
536	6300	10000	18.94	82	70½	55 x55	2-6
537	7300	11600	22.68	82	70½	55 x65¾	2-6
538	8300	13200	26.40	82	70½	55 x76½	3-6
539	9300	14800	30.12	82	70½	55 x87¼	3-6
5310	10300	16400	33.88	82	....	55 x98	3-6



Richardson End Feed Sectional Steam Boiler



Richardson Round Smokeless Boiler

SMOKELESS ROUND BOILERS
Ratings and Dimensions
Steam

Number	Height to Top of Outlet, Inches	Nominal Diam. of Grate Inches	Grate Area, Sq. Ft.	Size Smoke-Pipe Inches	Height of Waterline Inches	Number and Size of Outlets Inches	Number and Size of Inlets Inches	*Direct Radiation Boiler will supply at 8-hour firing period	Rating
S-432	53½	23	2.89	9	48¼	2-3	2-3	320 sq.ft.	700
S-532	57¼	23	2.89	9	52½	2-3	2-3	350 "	750
S-632	62	23	2.89	9	56¾	2-3	2-3	380 "	800
S-462	55½	26	3.70	10	49½	2-3½	2-3½	450 "	900
S-562	59¾	26	3.70	10	53¾	2-3½	2-3½	500 "	1000
S-662	64	26	3.70	10	58	2-3½	2-3½	550 "	1100
S-492	60	29	4.58	10	53½	2-3½	2-3½	630 "	1250
S-592	65⅜	29	4.58	10	58⅞	2-3½	2-3½	700 "	1350
S-692	70¾	29	4.58	10	64½	2-3½	2-3½	770 "	1450

Water

W-432	45¾	23	2.89	9	....	2-3	2-3	520 sq.ft.	1150
W-532	50	23	2.89	9	....	2-3	2-3	570 "	1225
W-632	54¼	23	2.89	9	....	2-3	2-3	620 "	1300
W-462	47⅛	26	3.70	10	....	2-3½	2-3½	725 "	1500
W-562	51⅜	26	3.70	10	....	2-3½	2-3½	800 "	1650
W-662	55⅝	26	3.70	10	....	2-3½	2-3½	875 "	1800
W-492	50½	29	4.58	10	....	2-3½	2-3½	1025 "	2050
W-592	55⅞	29	4.58	10	....	2-3½	2-3½	1125 "	2225
W-692	61¼	29	4.58	10	....	2-3½	2-3½	1225 "	2400

*Direct radiation boiler will supply, is based on the use of cast-iron radiation in a 70° F. temperature and with the assumption that the Boiler and Piping system is thoroughly covered in the usual manner. For churches, garages, schools, or where pipe coils, wall or indirect radiation is used, the tax on the boiler must be figured on a basis equivalent to cast-iron radiation as above. When coils or indirect water heaters are used in connection with steam and water boilers, for heating water for domestic purposes, additional capacity must be figured at the rate of 1½ square feet of direct radiation for a steam boiler; and 2½ square feet of direct radiation for a hot water boiler, for each gallon of water to be heated per hour.

Height of chimney for 23" series, 35 feet; 26" series, 40 feet; 29" series, 50 feet.
Inside area of chimney flue, 23" series, 96 sq. in.; 26" series, 96 sq. in.; 29" series, 144 sq. in.

RICHARDSON HOT-BLAST SMOKELESS BOILERS
End Feed Sectional Steam and Water

Special features of the "*Richardson*" Hot Blast Smokeless Boilers "C" Series.

They are made in sectional form and can be erected at any time, whether the building is new or old. This enables the boiler to be installed with a minimum handling expense.

The natural fire travel and draft eliminate excessive heights in chimneys.

Long smoke travel and no obstruction to the flames, aid combustion to the perfection point and utilize maximum heat from the fuel.

"Y" Flue Construction equalizes the circulation and assures a steady water line.

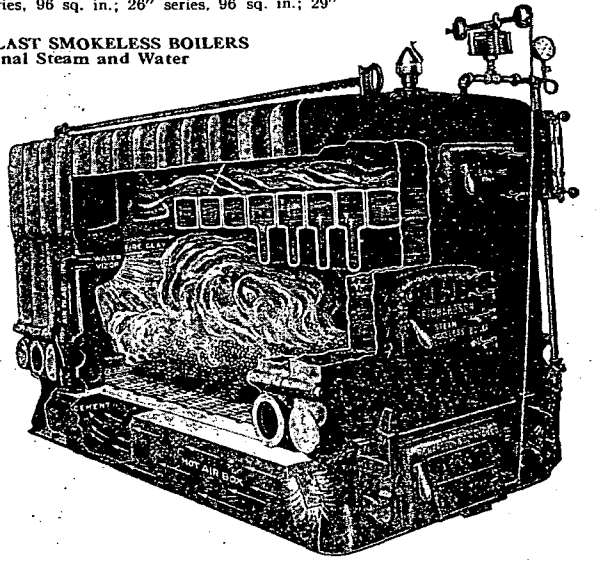
Overhanging prime heating surfaces are at the maximum, producing the highest evaporative power.

During the process of the fuel coking, gases are drawn back into a large chamber in front of the bridgewall, which has two port holes at the top center, making it impossible for gases to accumulate and explode.

The base is made in sections, permitting enlargement of a boiler if ever necessary.

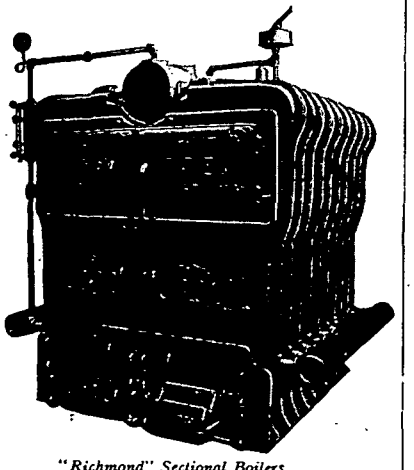
Fire door: Replacing of grates through fire door big enough for man to enter (15x20 inches) means important saving in time. The size of this door permits even distribution of fuel over the fire.

Made in sizes 1850-16,150 sq. ft. for steam
Made in sizes 3000-26,600 sq. ft. for water



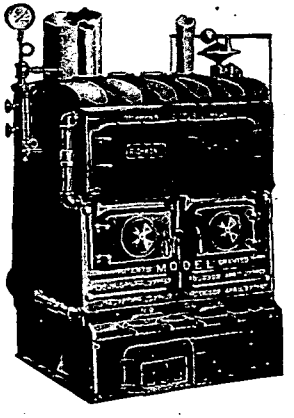
RICHMOND RADIATOR COMPANY

NEW YORK BOSTON CLEVELAND CHICAGO PHILADELPHIA HARRISBURG



"Richmond" Sectional Boilers

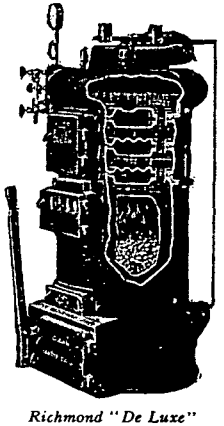
For heavy duty with all grades of Hard or Soft Coal, Coke, Lignite, Natural Gas and Fuel Oils.



"Richmond" Model Sectional

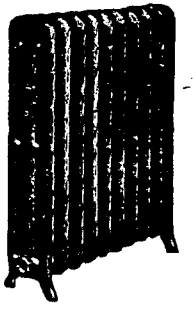
Specially designed for efficient heat surface, circulation, compactness and accessibility.

18", 22", 30" and 40" grates, 3 to 12 sections. Steam and Hot Water.



Richmond "De Luxe"

Mechanically far in advance of any other Round Boiler. A Code Boiler made with grates 17", 20", 23", 26", 29" in diameter. Steam and Hot Water.

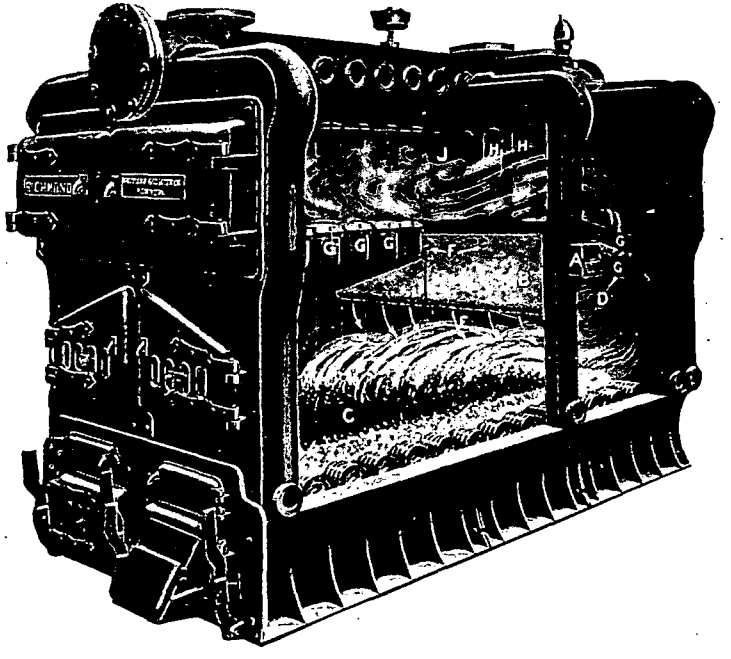


"Richmond" Radiators

An efficient, compact and graceful radiator, designed to give the utmost in heating surface and effective heating. Made in 1, 2, 3, 4 and 6 columns —window indirect and wall patterns.

CATALOGS OF BOILERS AND RADIATORS UPON REQUEST

RICHMOND RADIATOR COMPANY



"Richmond" Smokeless Boilers Burn Coal Smokelessly

Meets the Requirements of the Most Rigid Smoke Ordinances. A 53-inch Boiler, 7 to 16 Sections, Steam and Hot Water.

NEW POLICY OF BOILER RATINGS

All RICHMOND Boiler ratings are now based upon exact boiler output, that is the exact amount of direct cast iron radiation boilers will carry. In addition to uncovered piping—boiler covered. Positively eliminates the selection of a 700-800-foot boiler when actual radiation is but 450 feet. Complete data on the entire RICHMOND line will be found in the catalog of new ratings. May be obtained from headquarters or any branch office.

NEW ENGINEERING DATA BOOK—FREE!

Invaluable to every Heating Engineer. Contains reprints of all Official Codes, Data on Chimneys, Boiler and Pipe Coverings and reports of RICHMOND Boiler tests and ratings according to existing Codes. Records of tests on file with *Heating and Piping Contractors Association*. A copy of this helpful book of engineering information sent upon request.

The H. B. Smith Company

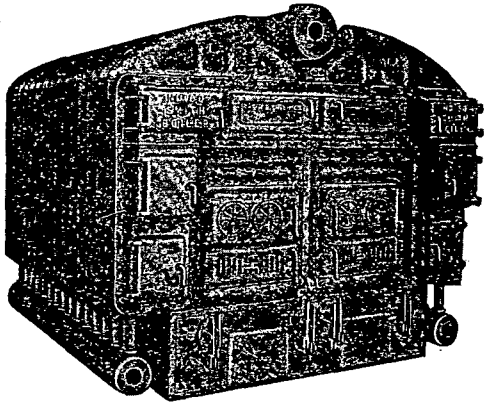
Works: Westfield, Mass.

WESTFIELD, MASS. 57 Main Street

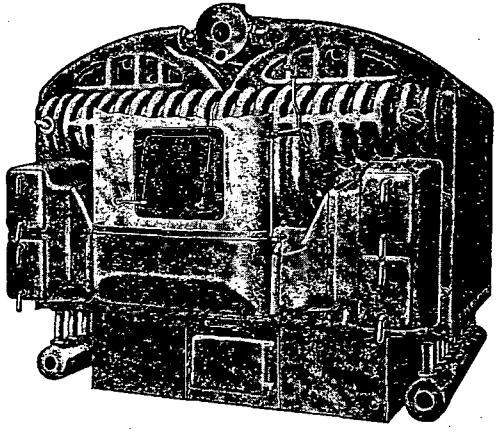
NEW YORK, 10 East 39th Street BOSTON, 640 Main Street, Cambridge

CLEVELAND, 1108 Webster Avenue, S.E. PHILADELPHIA, 49th St. and Grays Ave.

Manufacturers of Boilers and Radiators for Steam and Water Heating



No. 60 Smith Boiler—Front



No. 60 Smith Boiler—Back

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.

With Oxygen Torch

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

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.

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″	66″
Oval smoke pipe equivalent to	13½″ round	15½″ round	...	29½″ round

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
No. 60

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

Return Drums*

Steam Boilers

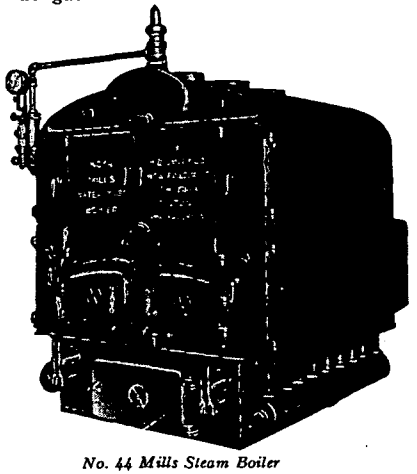
Outside diameter.....8 in.
Tapped for 2-in. lock-nut nipples.
Front ends tapped.....2½ in.
Rear ends tapped.....5 in.
Undersides tapped.....1¼ in.

Fire Tools and Steam Trimmings Furnished

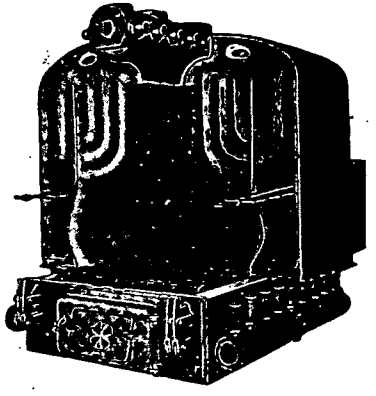
*When boiler is to be used for water warming, specify on order the size of supply and return pipe tappings. Tappings other than those listed are special. Order must specify size.

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 or fuel gas.



No. 44 Mills Steam Boiler

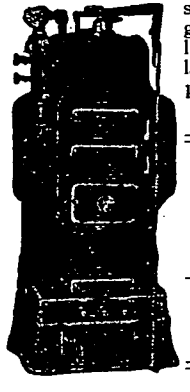


No. 44 Mills Boiler—Interior

Size of Boiler	Nominal Width Fire Pot Inches	Commercial Rating—Capacity in Sq. Ft.		Max. Allowable Working Pressure		
		Steam	Water	Steam	Water (Open Tank)	Water (Closed Tank)
No. 24	24	700 to 2025	1175 to 3350	15 lb.	30 lb.	15 lb.
No. 34	34	2000 to 5200	3300 to 8575	15 lb.	30 lb.	15 lb.
No. 44	44	3600 to 9000	5950 to 14,850	15 lb.	30 lb.	15 lb.
No. 48	48	4800 to 12,000	7925 to 19,800	15 lb.	60 lb.	30 lb.

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.



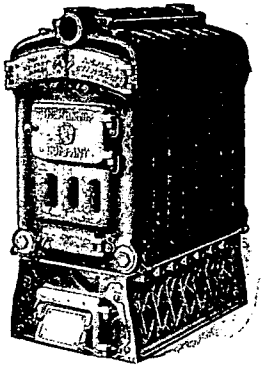
Commercial Ratings

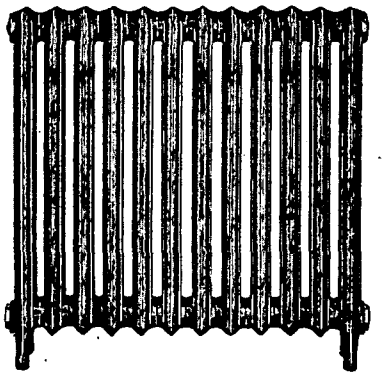
Diam. of Fire Pot Inches	Steam Rating Feet	Water Rating Feet
15 to 27	250 to 1000	425 to 1650

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.





"Princess" Water Radiator

Princess Direct Radiators

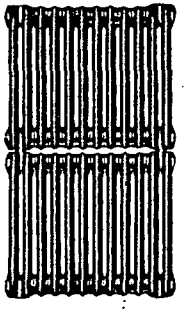
For sanitary reasons, radiators with wide spacing should be demanded.

If ordinary radiators are not sanitary enough for hospitals, they are not sanitary for the home. To meet hospital specifications some manufacturers make special radiators with wide spacing and charge an increased price.

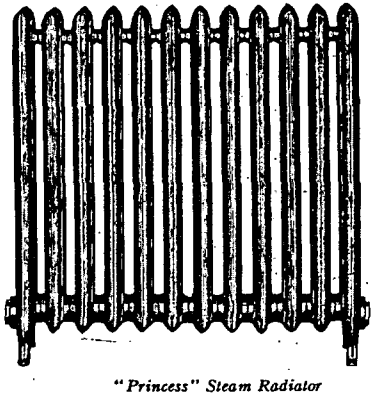
Princess Radiators are the standard radiators of The H. B. Smith Co. and are sold at regular list prices.

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. radiator 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.



"Princess" Wall Radiator



"Princess" Steam Radiator

Spencer Heater Company

Williamsport, Pa.

NEW YORK BOSTON PHILADELPHIA BALTIMORE BUFFALO ROCHESTER
DETROIT SYRACUSE ALBANY HARRISBURG SCRANTON

Builders of Spencer Heaters

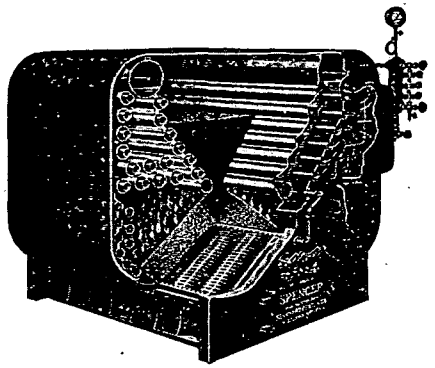
SPENCER HEATERS

Give uniform heat over long periods and use small size hard coal with least attention to the fire.

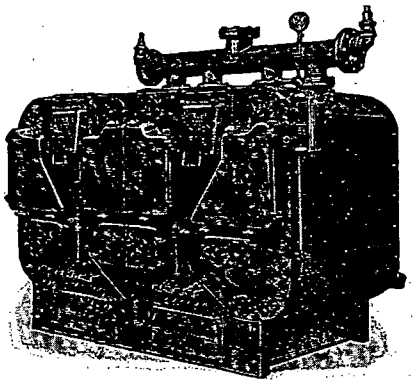
The magazine-feed feature is built into the heater and requires no adjustment. The magazine holds a supply of coal sufficient for 8 to 12 hours in severe weather or for a proportionately longer period in milder weather.

Spencer Heaters are economical and efficient.

Due to the magazine-feed feature of the Spencer Heater it is impracticable to obtain a firing period of less than 8 hours. Therefore ratings of Spencer Heaters are based upon an evaporation of 8 lbs. of water per lb. of coal burned, the rated evaporation having been obtained in actual test using fresh mined No. 1 Buckwheat coal as fuel.



50 Series. Spencer Tubular Heater



100 Series. Spencer Tubular Heater

SPENCER TUBULAR STEAM HEATERS

	Heater Number	Rating Sq. Ft. Radiation	Fire Surface Sq. Ft.	Heating Surface Sq. Ft.	Tapping Flow	Tapping Return	Overall Length Ins.	Overall Width Ins.	Water Line Ins.	Draft to Develop Rating Ins. H_2O	Size Chimney Flue
	15	2,000	12.00	282	2-4″	2-2½″	72½	62½	56	.23	16″x16″x50′
	17	2,500	13.50	309	2-4″	2-2½″	78½	62½	56	.24	16″x16″x55′
	19	3,000	15.00	337	2-4″	2-2½″	84½	62½	56	.25	16″x16″x60′
	20	3,500	16.50	365	2-4″	2-2½″	90½	62½	56	.26	16″x16″x65′
	21	4,000	18.00	393	2-4″	2-2½″	96½	62½	56	.27	16″x16″x65′
50 Series	3-45	4,500	18.05	389	2-5″	2-2½″	99½	81¼	59	.24	18″x18″x50′
50 Series	3-50	5,000	20.24	429	2-5″	2-2½″	105¾	81¼	59	.25	18″x18″x55′
50 Series	3-55	5,500	22.56	468	2-5″	2-2½″	112	81¼	59	.26	18″x18″x60′
50 Series	3-60	6,000	24.83	506	2-5″	2-2½″	118¼	81¼	59	.27	18″x18″x65′
50 Series	3-70	7,000	27.00	547	2-5″	2-2½″	124½	81¼	59	.28	18″x18″x70′
100 Series	3-80	8,000	30.35	560	1-8″	2-2½″	98	116⅛	66	.27	20″x20″x65′
100 Series	3-90	9,000	34.70	621	1-8″	2-2½″	104¼	116⅛	66	.28	20″x20″x65′
100 Series	3-105	10,500	39.05	683	1-8″	2-2½″	110½	116⅛	66	.29	22″x22″x65′
100 Series	3-120	12,000	43.40	745	1-8″	2-2½″	116¾	116⅛	66	.30	24″x24″x70′
100 Series	3-140	14,000	47.75	807	1-8″	2-2½″	123	116⅛	66	.32	24″x24″x70′
100 Series	3-160	16,000	52.10	869	1-8″	2-2½″	129¼	116⅛	66	.34	24″x24″x70′

Heaters No. 3-45 to 3-160 are furnished with steel jackets and 1½ in. Rockwool asbestos covering, also pipe header.

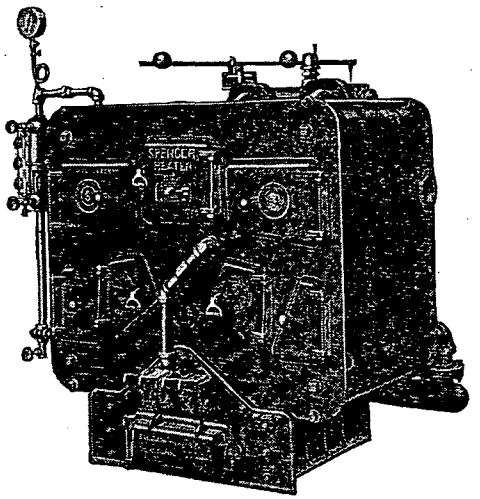
Heaters No. 15-21 are furnished with steel jackets only.

Chimney Flue sizes are based on a maximum Flue Temperature at Boiler Smoke outlet of 500 deg. fahr.

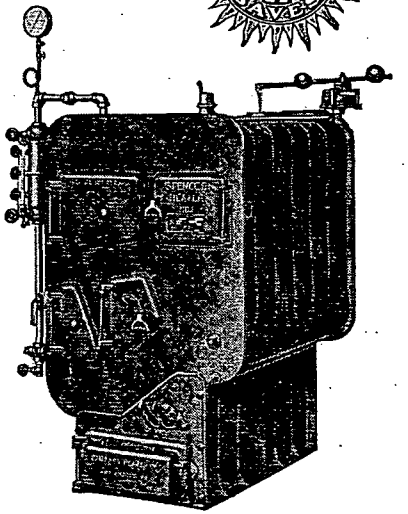
SPENCER HEATERS are adaptable for residences, apartment houses, churches, schools, public and commercial buildings, theatres, green houses, garages and all other types of buildings heated by low pressure steam, vapor, or hot water.

For over 25 years SPENCER HEATERS have been tried and tested under the most severe climatic conditions. There are thousands of successful installations throughout the entire country.

Write for illustrated catalog containing complete information.



No. 2 Series. Spencer Sectional Heater



No. 1 Series. Spencer Sectional Heater

SPENCER SECTIONAL STEAM HEATERS

Heater Number	Rating Sq. Ft. Radiation	Fire Surface Sq. Ft.	Tapping Flow	Tapping Return	Overall Length Ins.	Overall Width Ins.	Water Line Ins.	Draft to Develop Rating Ins. H_2O	Size Chimney Flue
1-5-S	600	2.26	1-4″	2-4″	48⅛	37⅞	50″	0.12	10″x10″x30′
1-6-S	750	2.82	1-4″	2-4″	54⅜	37⅞	50″	0.13	10″x10″x35′
1-7-S	900	3.38	1-4″	2-4″	60⅝	37⅞	50″	0.14	10″x10″x35′
1-8-S	1,050	3.95	1-4″	2-4″	66⅞	37⅞	50″	0.15	12″x12″x35′
1-9-S	1,200	4.51	1-4″	2-4″	73⅛	37⅞	50″	0.16	12″x12″x35′
2-6-S	1,300	5.64	2-4″	2-4″	68⅝	57⅞	50″	0.17	10″x10″x35′
2-7-S	1,600	6.77	2-4″	2-4″	74⅞	57⅞	50″	0.18	12″x12″x35′
2-8-S	2,000	7.90	2-4″	2-4″	81⅛	57⅞	50″	0.19	12″x12″x35′
2-9-S	2,400	9.03	2-4″	2-4″	87⅜	57⅞	50″	0.20	12″x12″x35′
2-10-S	2,800	10.16	2-4″	2-4″	93⅝	57⅞	50″	0.21	12″x12″x40′
2-11-S	3,200	11.28	2-4″	2-4″	99⅞	57⅞	50″	0.21	12″x12″x40′

SPENCER SECTIONAL WATER HEATERS

1-5-W	1,000	2.26	2-4″	2-4″	48⅛	37⅞	0.12	10″x10″x30′
1-6-W	1,250	2.82	2-4″	2-4″	54⅜	37⅞	0.13	10″x10″x35′
1-7-W	1,500	3.38	2-4″	2-4″	60⅝	37⅞	0.14	10″x10″x35′
1-8-W	1,750	3.95	2-4″	2-4″	66⅞	37⅞	0.15	12″x12″x35′
1-9-W	2,000	4.51	2-4″	2-4″	73⅛	37⅞	0.16	12″x12″x35′
2-6-W	2,100	5.64	2-4″	2-4″	68⅝	57⅞	0.17	10″x10″x35′
2-7-W	2,600	6.77	2-4″	2-4″	74⅞	57⅞	0.18	12″x12″x35′
2-8-W	3,200	7.90	2-4″	2-4″	81⅛	57⅞	0.19	12″x12″x35′
2-9-W	3,800	9.03	2-4″	2-4″	87⅜	57⅞	0.20	12″x12″x35′
2-10-W	4,500	10.16	2-4″	2-4″	93⅝	57⅞	0.21	12″x12″x40′
2-11-W	5,100	11.28	2-4″	2-4″	99⅞	57⅞	0.21	12″x12″x40′

The Thatcher Company

Boilers—Furnaces—Ranges

Since 1850

General Offices

Thatcher Building

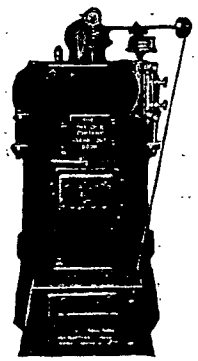
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Thatcher Round Boiler

THATCHER ROUND BOILER

No.	Rating Sq. Ft. Steam	No.	Rating Sq. Ft. Water	Actual Diam. Grate Inches	Grate Area Sq. Ft.	Height to Top Outlet		Height to Water Line Inches	Flow and Return Openings Inches
						Steam	Water		
19-0-S	300	19-0-W	500	19	2.04	46¾″	42½″	40	2-3
19-1-S	350	19-1-W	575	19	2.04	51¼″	47″	44½	2-3
19-2-S	400	19-2-W	650	19	2.04	55¾″	51½″	49	2-3
22-0-S	450	22-0-W	750	22	2.64	49¾″	44½″	42⅜	2-3
22-1-S	525	22-1-W	875	22	2.64	54⅜″	49⅜″	47	2-3
22-2-S	575	22-2-W	950	22	2.64	59″	54″	51⅝	2-3
25-0-S	600	25-0-W	1000	25	3.41	50¼″	44½″	42¾	2-4
25-1-S	675	25-1-W	1150	25	3.41	55¼″	49½″	47¼	2-4
25-2-S	750	25-2-W	1225	25	3.41	60¼″	54½″	52¾	2-4
28-0-S	800	28-0-W	1325	28	4.28	51⅛″	45½″	43¾	2-4
28-1-S	900	28-1-W	1500	28	4.28	56¼″	50⅝″	48⅞	2-4
28-2-S	1000	28-2-W	1650	28	4.28	61⅜″	55¼″	54	2-4

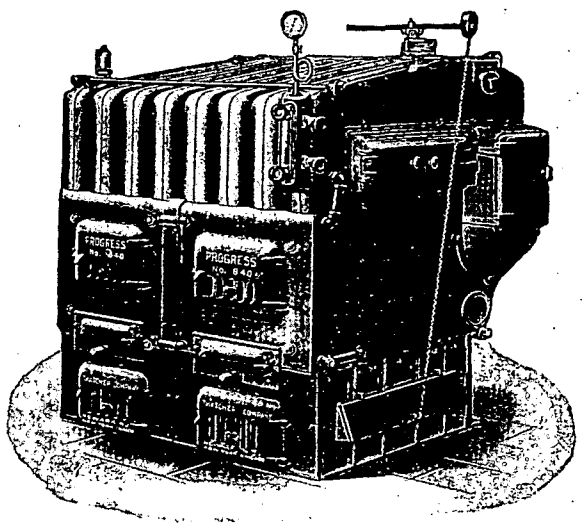
A round steam or hot water boiler. Especially designed to secure the greatest amount of heating surface by thin waterways, heavy corrugations, arms extending in to the fire-pot, and staggered passageways in the wheel sections.

THATCHER PROGRESS WITH LOW WATER LINE

The Thatcher Progress has such an unusually low water line that it can be used in the very lowest cellars without need of a boiler pit. The fact that either half of a twin boiler may be used alone is another big advantage.

The scientific construction embodies the triple fire travel principle which forces the smoke and hot gases to go three times the length of the boiler before going up the flue, thus obtaining all their heat units.

Furnished to care for any sized buildings, and adopted for coal or oil burning, the Progress has proven of value to all heating men.

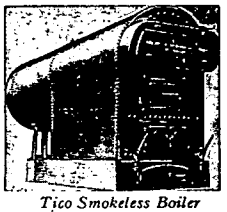


The Titusville Iron Works Company

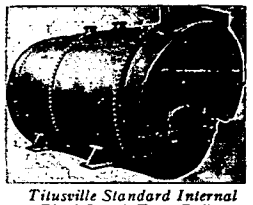
Titusville, Pennsylvania

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

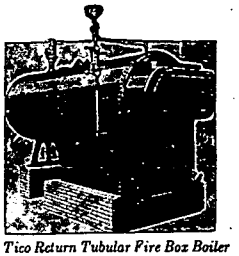
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WASHINGTON OFFICE.....732 Woodward Bldg.



Tico Smokeless Boiler



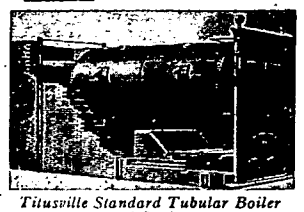
Titusville Standard Internal Fired Scotch Type Boiler



Tico Return Tubular Fire Box Boiler



Titusville Vertical Tubular Boiler



Titusville Standard Tubular 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 pneumatic riveting machines, 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.

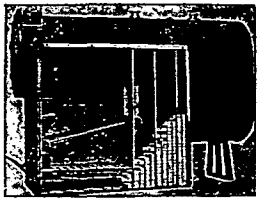
All boilers are made in strict accordance with the latest boiler code of the *American Society of Mechanical Engineers* and can be made, if desired, to conform to local requirements.

A large supply of material for all types of boilers is constantly carried and an adequate stock of completed TICOS and ACME FIREBOX Boilers is always ready for immediate shipment.

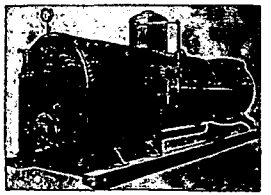
Thorough inspections and tests are constantly made during the construction and all workmanship and material is guaranteed first class in every respect.

In addition to the line of TITUSVILLE Boilers illustrated herewith we manufacture pneumatic and storage tanks of every description.

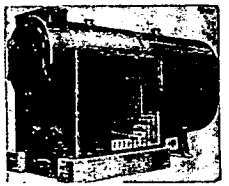
Descriptive bulletins will be sent on request.



Perfection Down Draft Smokeless Boiler



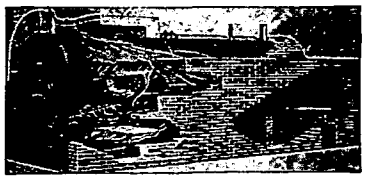
Titusville Open Bottom Locomotive Portable Boiler with Water Front



Titusville Perfection Boiler—Built in Sizes 25 H. P. to 200 H. P. from 15 lbs. to 150 lbs Working Pressure



Titusville Jacketed Tubeless Water Heater —for Heating Domestic Hot Water by Direct Circulation



Acme Smokeless Boiler—Brick Set Type for Steam and Hot Water Heating

UNITED STATES RADIATOR CORPORATION

GENERAL OFFICES: DETROIT, MICHIGAN

Manufacturers of Capitol Boilers and United States Radiators

Branch and Sales Offices

*Boston, Mass.	*Harrison, N. J.	*Cincinnati, Ohio	*St. Louis, Mo.
*Portland, Me.	*Philadelphia, Pa.	Detroit, Mich.	*Des Moines, Iowa
*Springfield, Mass.	*Baltimore, Md.	*Chicago, Ill.	*Omaha, Neb.
*Providence, R. I.	Buffalo, N. Y.	*Milwaukee, Wis.	*Denver, Colo.
*New Haven, Conn.	*Rochester, N. Y.	*Indianapolis, Ind.	*Portland, Ore.
*Troy, N. Y.	Pittsburgh, Pa.	*Louisville, Ky.	*Seattle, Wash.
New York, N. Y.	*Cleveland, Ohio	*St. Paul, Minn.	*San Francisco, Calif.
*Brooklyn, N. Y.	*Columbus, Ohio	*Kansas City, Mo.	
	Birmingham, Ala.		

*Assembling Plants located at points indicated by asterisk

Manufacturing Plants Located in Following Cities

Corry, Pa.; Detroit, Mich.; Dunkirk, N. Y.; Edwardsville, Ill.; Geneva, N. Y.; West Newton, Pa.

GUARANTEED HEATING

The problem of boiler ratings has been an acute and perplexing one. Some manufacturers rate their boilers conservatively. Others make extravagant claims. No two determine ratings on the same basis.

Associations of heating engineers and contractors have tried to protect themselves. They have fixed certain standards by which published ratings should be judged. But we find the standards in one city conflicting with those of another.

Boiler ratings consequently have come to mean little. They cannot be used for accurate comparison between different makes of boilers. They are an uncertain measure of the proper size of boiler required for a certain building.

The United States Radiator Corporation has now put an end to all the confusion.

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 definitely determined and is officially published herewith.

And we have gone still farther—*Capitol capacities are guaranteed in writing.* Only the advanced design, the dependability and mechanical accuracy of Capitol Boilers could make possible such a positive assurance of heating capacity.

When the needed radiating surface is known and contributing factors checked, the selection of the proper Capitol Boiler becomes simple, sure and safe.

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 listed herein 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.

STANDARD REQUIREMENTS

A guarantee of size of boiler for specified amount of direct cast iron radiation must be based upon certain standard requirements.

Direct Cast Iron Radiation: It is assumed that direct cast iron radiation will emit 240 B.t.u. per hour for steam, and 150 B.t.u. per hour for water, therefore, all radiation must be reduced to this heat emission basis.

The amount of radiation required on this basis shall be computed as outlined in our catalogue, or from methods adopted by either the *Heating and Piping Contractors' National Association,* or the American Society of Heating and Ventilating Engineers.

Corrections: Under ordinary conditions approximate corrections will reduce the following loads to their equivalent of direct cast iron radiation:

Direct-indirect, multiply by..... 1.25
Indirect, multiply by..... 1.50

Blast Coils: Determine condensation in pounds of steam per hour and multiply by 4.

Domestic Hot Water Supply: Storage tank capacity in gallons—for steam multiply by 2; for water multiply by 3.2

Allowances: The boiler size guaranteed for direct cast iron radiation includes allowances for heat loss of piping system and peak load. Where the actual surface in square feet of the piping system exceeds 25 per cent of the direct cast iron radiation for steam, or 35 per cent for water, additional allowances shall be made for the extra surface.

Draft: The boiler shall be attached to a chimney providing sufficient draft to consume with proper combustion the required amount of fuel per hour.

Fuel: The size of boiler recommended is based upon the use of a free-burning coal not smaller than nut size and having a heat value of at least 13,000 B.t.u. When the coal to be used has a heat value less than 13,000 B.t.u., the direct cast iron radiation shall be multiplied by the factor corresponding to heat value of the coal.

Heat Value of Coal in B.t.u. per Lb.	Factor	Heat Value of Coal in B.t.u. per Lb.	Factor	Heat Value of Coal in B.t.u. per Lb.	Factor
13,000	1.00	10,500	1.37	8,000	1.92
12,500	1.07	10,000	1.46	7,500	2.06
12,000	1.14	9,500	1.56	7,000	2.21
11,500	1.21	9,000	1.67	6,500	2.36
11,000	1.29	8,500	1:79	6,000	2.53

AMOUNT OF DIRECT CAST IRON RADIATION EACH CAPITOL BOILER IS GUARANTEED TO CARRY

Boiler Size No.	Direct Cast Iron Radiation Load, Sq. Ft.		Boiler Size No.	Direct Cast Iron Radiation Load, Sq. Ft.	
	Steam	Water		Steam	Water
Capitol Boilers—Square Type					
184	200	330	238	2100	3465
185	300	495	239	2400	3960
186	400	660	240	2500	4125
187	500	825	4106	2000	3300
204	350	580	4107	2500	4125
205	500	825	4108	3000	4950
206	625	1030	4109	3500	5775
207	750	1240	4110	4000	6600
255	750	1240	4111	4500	7425
256	925	1525	WN276	3700	6105
257	1125	1855	WN277	4300	7095
258	1300	2145	WN278	4900	8085
G276	800	1320	WN279	5500	9075
G277	980	1620	WN280	6100	10065
G278	1160	1920	WN281	6700	11055
G279	1350	2220	WN282	7300	12045
235	1200	1980	WN283	7900	13035
236	1500	2475	WN284	8500	14025
237	1800	2970			
Capitol Boilers—Smokeless Type					
627	1000	1650	1140	4500	7425
727	1225	2020	1240	4900	8085
827	1450	2390	1340	5400	8910
927	1675	2760	750	4700	7755
1027	1900	3135	850	5350	8825
1127	2125	3505	950	5850	9655
1227	2350	3875	1050	6500	10725
740	2500	4125	1150	7000	11550
840	3000	4950	1250	7650	12620
940	3500	5775	1350	8150	13450
1040	4050	6680			

Capitol Dependable Smokeless Boilers

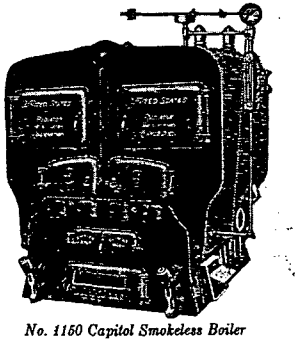
Smokeless combustion of bituminous coal at the lowest cost is now assured with a new degree of certainty by Capitol Smokeless Boilers.

"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 completing 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.

This mechanical precision of combustion which saves fuel and minimizes smokeless uncertainty is typical of every detail in the progressive design and careful construction of Capitol Smokeless Boilers.



No. 1160 Capitol Smokeless Boiler

Capitol Smokeless Boilers—50" Series

For economy of fuel, ease of operation and dependable heat in buildings requiring 4700 to 8150 square feet with steam heat or 7755 to 13,450 square feet with hot water, Capitol Series 50-inch Smokeless Boilers stand second to no other boiler.

Capitol assembly, testing, and marking insure correct installation. No more skill or attention is necessary to stoke them for the smokeless, low-cost consumption of all bituminous coals including lignite than is required to fire ordinary anthracite-burning boilers. The simple coking method of firing is all that is needed (pushing a portion of the incandescent coals back and putting the green fuel in front).

The main air supply is admitted under the grates and through the fuel bed. After passing through four inches of live coals the oxygen in the air becomes exhausted. Additional air is taken from the ashpit, and drawn up through carefully proportioned and permanently fixed passages in the front of the boiler which open at a point just above the fuel bed.

As the heated air and volatile gases, distilled from the fuel, rush toward the back they are deflected downward by a Curtain section. Then, as they pass under, they are again charged with preheated air from another inlet in the Curtain. In boilers of eleven sections or larger, a bridgewall (which is designed for a fire-brick lining) retards their progress and in smaller sizes they meet the back wall. The fresh oxygen and heated volatile gases are

forced to thoroughly mix and complete combustion is secured.

Twice more, three times in all, the gases are forced to travel through flues the full length of the boiler in constant contact with the largest possible heating surface, giving up to the water the maximum number of heat units before passing out of the boiler.

When the fire is banked at night, the deep fuel bed slowly cokes the coal forming an incandescent bed that ignites

RADIATOR LOADS AND DIMENSIONS

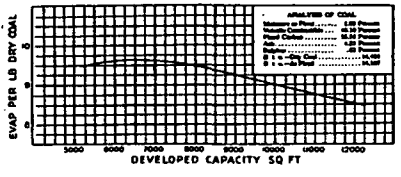
Boiler No.	*Direct Cast Iron Radiator Loads, Sq. Ft.		Height of Water Line, Inches	Grate Area Sq. Ft.	Coal Capacity, Cu. Ft.	Outlets and Inlets	Min. Chimney Sizes	
	Steam	Water					Height Feet	Dimensions Inches
750	4700	7755	66	18.29	29.67	3–5″	55	24 x 24
850	5350	8825	66	21.33	34.68	4–5″	60	24 x 24
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

*See Guaranteed Heating.
Height including trimmings 92 inches; width 82 inches
Specify if back or top outlet smoke hood is required.

the fresh charge in the morning and enables the boiler to reach its full capacity, easily and quickly.

The efficiency of the 50-inch series of Capitol Smokeless Boilers is shown strikingly by the typical performance curve below. The chart is based on many individual tests and the ratings are fixed conservatively. Notice the high volatile coal used for these tests.

PERFORMANCE CURVE No. 1150 CAPITOL BOILER



Capitol Smokeless Boilers—40″ Series

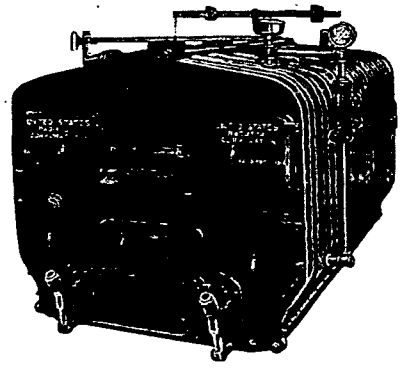
The Capitol Testing Laboratory has gone even farther than designing the most efficient smokeless boilers known. The 40-inch series has a 49-inch water line. No lower water line is necessary for any room with a ceiling high enough to allow men to work.

Not only fuel is saved; building costs are cut. No pit is needed. Construction savings alone, particularly where water in the basement must be guarded against and where foundations must be cut in rock, frequently pay for the entire heating plant. For large installations in such locations a tandem of 40-inch Capitol Boilers is often used in preference to a single boiler of larger size.

Important as this exclusive advantage is, however, it is secondary to the remarkable economy that results from the efficient operation of the Capitol 40-inch series.

With no pit required and no base section on this boiler, *installation is simplified. Any bituminous coal or lignite* may be used successfully; burned economically and smokelessly by any ordinary fireman.

Auxiliary air is admitted just above the fuel bed through passageways cast across the entire width of the front boiler section. The size of the air passages are correctly proportioned by the Capitol Testing Laboratory and need no adjusting. The greater portion of the air is taken from the ashpit. The remainder enters the passageways through openings in the clinker door. The amount of air drawn



No. 1140 Capitol Smokeless Boiler

in is automatically regulated to the rate of combustion in the exact amounts required.

This pre-heated air with its original oxygen sweeps across the fuel bed until it reaches a water-containing Curtain cast in a section near the back, which forces it to mingle with the gases as they pass beneath it.

Then they hit the lower, solid portion of a water-filled bridgewall (which requires no fire-brick), mix completely,

RADIATOR LOADS AND DIMENSIONS

Boiler No.	*Direct Cast Iron Radiator Loads, Sq. Ft.		Height of Water Line, Inches	Grate Area Sq. Ft.	Coal Capacity, Cu. Ft.	Outlets	Min. Chimney Sizes	
	Steam	Water					Height Feet	Dimensions Inches
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

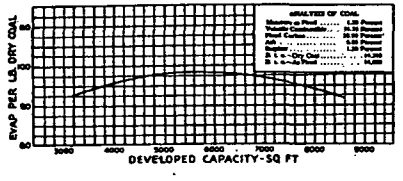
*See Guaranteed Heating.
Height including trimmings 71 inches; width 75 inches.
Equipped with combination top and back outlet smoke-hood.

and every smoke-producing particle is turned into heat before the gases pass through two openings in the upper portion of the bridgewall.

Back to the front of the boiler they must go, through two bottom flues and then return through two top flues, heating water every inch of the way, before they pass out of the boiler.

Without the foregoing facts the performance chart shown below might be hard to believe. Any fair test will substantiate this curve of efficiency that has no equal in the smokeless boiler field.

PERFORMANCE CURVE No. 1140 CAPITOL BOILER



Capitol Smokeless Boilers—27″ Series

Smokeless boilers are as desirable for large residences and small apartments as they are for larger commercial buildings, since smoke is a particular nuisance around homes. In addition, smokeless operation means greatest fuel economy in small installations as well as large.

To meet this large and growing demand; the Capitol *27-inch series Smokeless Boiler has been designed.*

Capitol ease of operation and mechanical certainty of proper auxiliary air supply, important in the larger sizes, become a necessity in a small installation which has not an attendant who devotes as much time to its care.

Any fireman can shovel soft coal into a 27-inch series Boiler and cperate it smokelessly. No special skill or attention is required.

Auxiliary air is admitted through fixed openings in the fire door which never need adjusting. Together with the volatile gases it sweeps toward the back. They meet an inverted bridgewall or curtain. Are deflected downward. As they pass under, they receive an additional supply of oxygen from a slot in the curtain. Then, hitting the rear wall, the oxygen mixes thoroughly with the gases and combustion is completed in the back of the fire box.

All the smoke is burned before the gases enter the flues. Twice more they travel the full length of the boiler, getting the utmost heating value out of every pound of coal.

RADIATOR LOADS AND DIMENSIONS

Boiler No.	*Direct Cast Iron Radiator Loads, Sq. Ft.		Height of Water Line, Inches	Grate Area Sq. Ft.	Coal Capacity, Cu. Ft.	Outlets	Min. Chimney Sizes	
	Steam	Water					Height Feet	Dimensions Inches
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

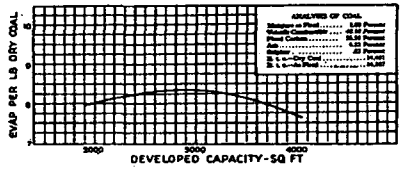
*See Guaranteed Heating.
Height including trimmings 68½ in.; width 50¾ in.
Specify if back or top outlet smoke hood is required.

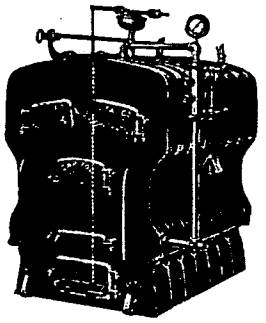
Banking the fire is as simple as stoking it. When the main drafts are closed, the green coal cokes slowly in the deep fire box. An incandescent bed is formed that quickly ignites the fresh fuel shoveled in the next morning and swiftly floods the house or apartment with grateful warmth.

Every detail in the Capitol 27-inch series Smokeless Boiler is likewise designed for easy and reliable operation. Even the flue doors are extra large, a convenience in keeping the flues clean, although Capitol smokeless combustion minimises the soot, the heat losses it causes, and the task of cleaning it out.

The high heating efficiency of Capitol 27-inch series Smokeless Boilers over a remarkably wide range of operating capacities, is clearly shown in the authoritative performance curve given below.

PERFORMANCE CURVE No. 1127 CAPITOL BOILER





No. 887 Capitol Smokeless Boiler

CAPITOL FIVE COLUMN RADIATORS

No. of Sections	*Length Inches	Surface 37″ Height 5 sq. ft. per Sec.	32″ Height 4.3 sq. ft. per Sec.	26″ Height 3.4 sq. ft. per Sec.	23″ Height 2.9 sq. ft. per Sec.	20″ Height 2.5 sq. ft. per Sec.
2	5	10	8.6	6.8	5.8	5.0
3	7½	15	12.9	10.2	8.7	7.5
4	10	20	17.2	13.6	11.6	10.0
5	12½	25	21.5	17.0	14.5	12.5
6	15	30	25.8	20.4	17.4	15.0
7	17½	35	30.1	23.8	20.3	17.5
8	20	40	34.4	27.2	23.2	20.0
9	22½	45	38.7	30.6	26.1	22.5
10	25	50	43.0	34.0	29.0	25.0
11	27½	55	47.3	37.4	31.9	27.5
12	30	60	51.6	40.8	34.8	30.0
13	32½	65	55.9	44.2	37.7	32.5
14	35	70	60.2	47.6	40.6	35.0
15	37½	75	64.5	51.0	43.5	37.5
16	40	80	68.8	54.4	46.4	40.0
17	42½	85	73.1	57.8	49.3	42.5
18	45	90	77.4	61.2	52.2	45.0
19	47½	95	81.7	64.6	55.1	47.5
20	50	100	86.0	68.0	58.0	50.0
21	52½	105	90.3	71.4	60.9	52.5
22	55	110	94.6	74.8	63.8	55.0
23	57½	115	98.9	78.2	66.7	57.5
24	60	120	103.2	81.6	69.6	60.0
25	62½	125	107.5	85.0	72.5	62.5

*Allow ½ inch for each bushing in estimating length of radiators.

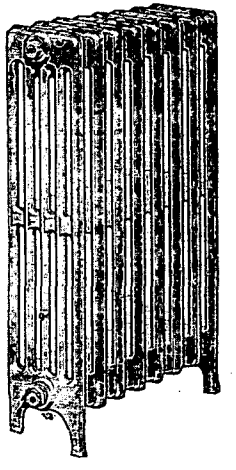
Each section is 8⅛ inches wide. Width of legs, 8¾ inches.

Above Radiators tapped 1½ inches at top and bottom.

Distance from floor to center of lower tapping, 4½ inches.

Distance from floor to center of upper tapping:

37″ Height — 35¼″
32″ Height — 30¼″
26″ Height — 24½″
23″ Height — 21¼″
20″ Height — 18⅜″



Universal Smokeless Boiler Company

100% WATER TUBE, SELF-CLEANING BOILERS

Factory and Main Office - - RAVENNA, OHIO

Guarantee

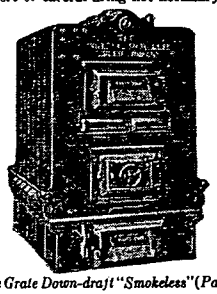
On installations under 5000 ft. steam, we guarantee our boilers to provide sufficient steam to take care of 50 per cent of their rated capacity shown below. On installations over 5000 ft. steam 60 per cent of the rated capacity.

This guarantee is based on using bituminous high volatile coal similar to "Pittsburgh Vein" run-of-mine. Four-hour firing period.

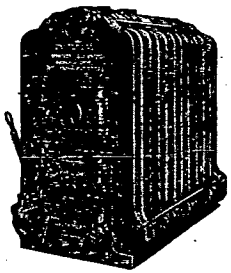
Our SMOKELESS BOILERS comply with the law and are guaranteed to pass the smoke ordinance of all cities, using bituminous coal.

The smokeless feature is fool-proof.

Expert or careful firing not necessary.



Double Grate Down-draft "Smokeless" (Patented)



Single-Grate, Low Water Line (Patented)

"Smoke-Preventing"

Equipped with hot blast oxidizing tuyeres, and high temperature cement baffle section.

24" SINGLE-GRATE, UP-DRAFT. "SMOKE-PREVENTING"

Water-line 47 in. Width overall 36 in. Height overall 57 in.

Steam Boiler No.	Steam Rating	Total No. of Sections	Water Boiler No.	Water Rating
S-531	2160	6	W-531	3460
S-541	2880	7	W-541	4600
S-551	3600	8	W-551	5760
S-552	3900	9	W-552	6240
S-553	4200	10	W-553	6720
S-562	4320	10	W-562	6900
S-572	5040	11	W-572	8000
S-573	5400	12	W-573	8600
S-582	5760	12	W-582	9200
S-592	6480	13	W-592	10360
S-593	6830	14	W-593	10920

CAST IRON SECTIONAL BOILERS

100 Per Cent Water Tube Construction

36" SERIES—DOUBLE-GRATE, DOWN-DRAFT. "SMOKELESS"

Water-line 48 in. if base of boiler is set in a pit 13 in. deep.
Width overall 49 in. Height overall 73 in. Returns 4–2½ in.

Steam Boiler Number	Steam Rating	Water Boiler Number	Water Rating	Grate Area Square Feet	Grate Length Inches	No. Sections	Approximate Boiler Length Inches	Outlets—3½ in.	Smallest Dimensions Chimney Inside, In.	Height Chimney Sea Level—Square Feet
S-32	3800	W-32	6080	9.75	19	7	45	2	15	45
S-42	4500	W-42	7200	13.0	24	8	51	2	15	45
S-43	5200	W-43	8320	13.0	24	9	57	2	15	45
S-53	5700	W-53	9120	16.26	30	10	64	3	16	50
S-54	6400	W-54	10240	16.26	30	11	70	3	16	50
S-64	7100	W-64	11360	19.5	36	12	77	3	16	50
S-65	7800	W-65	12480	19.5	36	13	85	3	16	50
S-74	8150	W-74	13040	22.74	42	13	85	4	17	55
S-75	8500	W-75	13600	22.74	42	14	92	4	17	55
S-84	8850	W-84	14160	26.0	48	14	92	4	18	60
S-85	9200	W-85	14720	26.0	48	15	99	4	18	60
S-95	9750	W-95	15700	29.26	54	16	105	5	19	65
S-96	10150	W-96	16240	29.26	54	17	111	5	19	65
S-97	10500	W-97	16800	29.26	54	18	117	5	19	65
S-106	11000	W-106	17600	32.52	60	18	120	5	20	70
S-107	11250	W-107	18000	32.52	60	19	127	5	20	70
S-108	12100	W-108	19360	32.52	60	20	134	5	20	70
S-117	12250	W-117	19600	36.0	66	20	140	6	21	75
S-118	12650	W-118	20240	36.0	66	21	147	6	21	75
S-119	13000	W-119	20800	36.0	66	22	153	6	21	75
S-1110	15000	W-1110	24000	36.0	66	23	160	6	21	75

24" SERIES—DOUBLE-GRATE, DOWN-DRAFT. "SMOKELESS"

Water-line 57 in. Height overall 67 in. Outlets 4 in. Width 36 in. Returns 2 in.

S-432	1650	W-432	2640	5.0	15	7	35	....	12	40
S-433	1800	W-433	2880	5.0	15	8	40	....	12	40
S-443	2200	W-443	3620	6.60	20	9	45	....	15	45
S-444	2400	W-444	3840	6.66	20	10	50	....	15	45
S-454	2700	W-454	4320	8.32	25	11	60	....	16	45
S-455	3000	W-455	4800	8.32	25	12	65	....	16	45
S-465	3250	W-465	5200	10.0	30	13	70	....	16	45
S-466	3450	W-466	5520	10.0	30	14	75	....	18	45
S-476	3800	W-476	6080	11.16	35	15	80	....	18	50
S-477	4000	W-477	6400	11.18	35	16	85	....	18	50

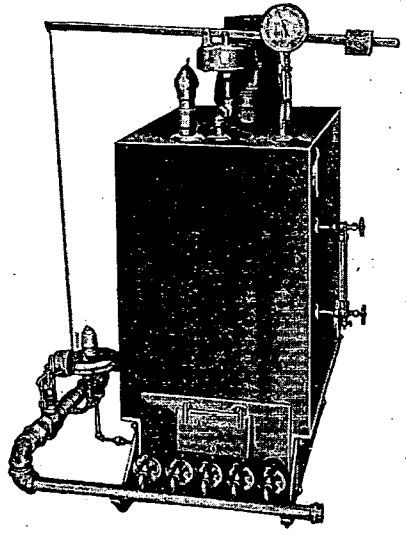
36" SINGLE-GRATE, UP-DRAFT. "SMOKE-PREVENTING"

Water-line 48 in. Width overall 49 in. Height 60 in.

Steam Boiler No.	Steam Rating	Total No. Sections	Water Boiler No.	Water Rating
S-331	4000	6	W-331	6400
S-332	4675	7	W-332	7500
S-342	5350	8	W-342	8560
S-343	6000	9	W-343	9600
S-352	6650	9	W-352	10640
S-353	7100	10	W-353	11360
S-354	7550	11	W-354	12080
S-362	8000	10	W-362	12800
S-363	8450	10	W-363	13520
S-364	8900	12	W-364	14240
S-373	9350	12	W-373	14960
S-374	9800	13	W-374	15680
S-375	10200	14	W-375	16320
S-383	10650	13	W-383	17040
S-384	11100	14	W-384	17760
S-385	11550	15	W-385	18480
S-394	12000	15	W-394	19200
S-395	12450	16	W-395	19920
S-396	12900	17	W-396	20640
S-397	13350	18	W-397	21260

Universal Cast Iron Sectional Gas Boilers

For Natural or Manufactured Gas



Patented

Universal Gas Boiler with Metallic Jacket. The front panel is easily removable for cleaning.

With Special Circulating Section and Metallic Jacket lined with Super-Firefelt

Boiler Number	Steam Rating	Number Sections	List Price	Approximate Shipping Weight
31 T S	380	3	$208.00	735
41 T S	480	4	255.00	1137
51 T S	660	5	312.00	1300
61 T S	840	6	367.00	1475
32 T S	1020	7	421.00	1629
42 T S	1200	8	460.00	1789
52 T S	1380	9	512.00	1954
62 T S	1560	10	564.00	2116
72 T S	1740	11	615.00	2281
33 T S	1920	12	665.00	2445
43 T S	2100	13	714.00	2606
53 T S	2280	14	762.00	2767
63 T S	2460	15	809.00	2928
73 T S	2640	16	863.00	3094
34 T S	2820	17	909.00	3227
44 T S	3000	18	962.00	3319
54 T S	3180	19	1006.00	3582
64 T S	3360	20	1059.00	3741
74 T S	3540	21	1102.00	3938
35 T S	3720	22	1154.00	4095
45 T S	3900	23	1196.00	4257
55 T S	4080	24	1248.00	4431
65 T S	4260	25	1288.00	4604
75 T S	4440	26	1339.00	4769
36 T S	4620	27	1379.00	4932
46 T S	4800	28	1429.00	5100
56 T S	4980	29	1467.00	5263
66 T S	5160	30	1518.00	5433
76 T S	5340	31	1554.00	5668

STEAM BOILERS—Height to water-line 29 in. Height to top flue opening 38 in.

If METALLIC JACKET is not wanted, deduct from the net, $13.50 for a 3-Section Boiler and $1.25 net for each additional section over three

STEAM OR VAPOR BOILERS

Outlets, 2–3".

Fifteen-section boilers and over have one extra 1½" outlet for every 10 sections.

Returns, 2–3".

Trimmings — Safety valve, steam gauge, water glass complete with try-cock, automatic gas control valve, automatic steam pressure regulator, metal bellows type; pilot, complete with lava tip and cut-off valve.

WATER BOILERS

Outlets, 2–3".

Returns, 2–3".

Trimmings—Thermometer, altitude gauge, automatic gas control valve, pilot.

With Plain Section and Metallic Jacket lined with Super-Firefelt

Number	Steam Rating	Water Rating	Number Sections	List Price Water	List Price Steam	Approx. Shipping Weight
31 P S and P W	300	480	3	$146.00	$188.00	715
41 P S and P W	400	665	4	194.00	227.00	1017
51 P S and P W	550	905	5	241.00	275.00	1150
61 P S and P W	700	1145	6	288.00	322.00	1293
32 P S and P W	850	1385	7	332.00	369.00	1419
42 P S and P W	1000	1625	8	363.00	399.00	1549
52 P S and P W	1150	1865	9	406.00	445.00	1684
62 P S and P W	1300	2105	10	450.00	488.00	1816
72 P S and P W	1450	2345	11	492.00	533.00	1951
33 P S and P W	1600	2585	12	534.00	575.00	2085
43 P S and P W	1750	2825	13	575.00	617.00	2216
53 P S and P W	1900	3065	14	616.00	658.00	2347
63 P S and P W	2050	3305	15	654.00	698.00	2478
73 P S and P W	2200	3545	16	700.00	744.00	2614
34 P S and P W	2350	3785	17	737.00	784.00	2717
44 P S and P W	2500	4025	18	782.00	828.00	2879
54 P S and P W	2650	4265	19	819.00	867.00	3012
64 P S and P W	2800	4505	20	863.00	911.00	3141
74 P S and P W	2950	4745	21	899.00	949.00	3278
35 P S and P W	3100	4985	22	943.00	993.00	3405
45 P S and P W	3250	5225	23	977.00	1029.00	3537
55 P S and P W	3400	5465	24	1021.00	1073.00	3681
65 P S and P W	3550	5705	25	1054.00	1108.00	3824
75 P S and P W	3700	5945	26	1098.00	1151.00	3959
36 P S and P W	3950	6185	27	1130.00	1185.00	4092
46 P S and P W	4100	6425	28	1173.00	1228.00	4231
56 P S and P W	4250	6665	29	1204.00	1261.00	4363
66 P S and P W	4400	9605	30	1246.00	1304.00	4503
76 P S and P W	4550	7145	31	1276.00	1335.00	4708

STEAM BOILERS—Height to top flue opening 38 in. Height to water-line 26 in.
WATER BOILERS—Height to top flue opening 38 in.

Utica Heater Company

UTICA, New York

365 E. Illinois St.
CHICAGO, ILL.

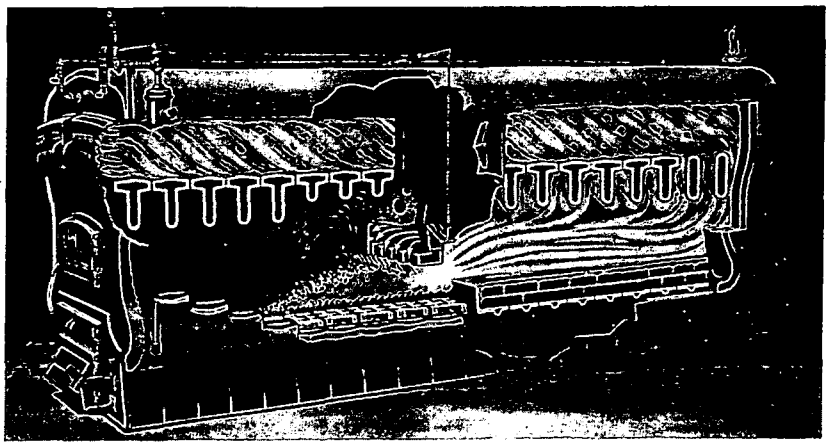
628 Union Building
CLEVELAND, O.

1843 Grand Central Term'l
NEW YORK, N. Y.

Representatives In Principal Jobbing Centers

Utica-Imperial SUPER-SMOKELESS Boilers

Burn Soft Coal Smokelessly—Use Any Available Fuel



Patented January 10, 1922.

Utica-Imperial SUPER-SMOKELESS Boiler

Cut-away View, Showing Primary and Secondary Combustion Chambers and Air Inlets

SUPER-SMOKELESS BOILERS—

Are designed to operate smokelessly when burning soft coal. They utilize any available fuel, burning either hard coal, soft coal, lignite, coke, fuel oil or gas with exceptional efficiency and decided economy.

ELIMINATION OF SMOKE—

Is attained by consuming the smoke and soot within the boiler. This complete combustion is due to the admission of highly heated air through water-jacketed inlets, in the baffle wall at the rear of the fire box. The admixture of oxygen at this point instantly converts the heavy gases into incandescent flames of unusual heating capacity. The smoke and soot are actually used as fuel and clean chimney and flues are maintained at all times.

SUPER-SMOKELESS Boilers comply with the most rigid smoke ordinances and are recommended by foremost heating engineers and leading architects for important buildings.

CONSTRUCTION—

SUPER-SMOKELESS Boilers have a single grate and are of sectional cast iron construction. Cast iron is highly resistant to corrosion and preferable to steel where low pressure permits using it. The sectional construction permits easy handling in shipment as well as installation in completed buildings.

The baffle wall is a specially designed water section of the boiler. It has a series of water-jacketed air inlets above the firebed and is covered on the side facing the fire by high-test plastic firebrick.

OPERATION—

SUPER-SMOKELESS Boilers are extremely simple to operate. No special skill or high priced help is required. Long firing periods are the rule and little care or attention is required for successful, smokeless operation.

Capacities and Dimensions of Utica-Imperial SUPER-SMOKELESS Boilers

Number Steam	Steam Ratings, Sq. Ft. High Output	Steam Ratings, Sq. Ft. High Efficiency	Number Water	Water Ratings, Sq. Ft. High Output	Water Ratings, Sq. Ft. High Efficiency	Grate Area Sq. Ft.	Length of Sections Inches	Length of Sections and Smoke Box Inches
S-245	1600	1200	W-245	2560	1920	5.00	37¼	48½
S-246	2075	1500	W-246	3320	2400	6.25	45½	56¾
S-247	2550	1800	W-247	4080	2880	7.50	53¾	63½
S-248	3025	2100	W-248	4840	3360	8.75	62	71½
S-249	3500	2400	W-249	5600	3840	10.00	70¼	79¾
S-335	3000	2000	W-335	4800	3200	7.32	37¼	49½
S-336	3750	2500	W-336	6000	4000	9.10	45½	57¾
S-337	4500	3000	W-337	7200	4800	10.87	53¾	66
S-338	5250	3500	W-338	8400	5600	12.65	62	72½
S-339	6000	4000	W-339	9600	6400	14.42	70¼	80¾
S-3310	6750	4700	W-3310	10800	7520	16.20	78½	89
S-405	4125	2750	W-405	6600	4400	9.68	37¼	49¼
S-406	5250	3500	W-406	8400	5600	12.03	45½	57½
S-407	6375	4250	W-407	10200	6800	14.38	53¾	65¾
S-408	7500	5000	W-408	12000	8000	16.73	62	74
S-409	8625	5750	W-409	13800	9200	19.08	70¼	82¼
S-4010	9750	6500	W-4010	15600	10400	21.43	78½	90½
S-4011	10875	7250	W-4011	17400	11600	23.77	86¾	97
S-4012	12000	8000	W-4012	19200	12800	23.77	95	105¼
S-4013	12700	8750	W-4013	20320	14000	23.77	103¼	113½
S-4014	13500	9500	W-4014	21600	15200	23.77	111½	121¾
S-4015	14250	10250	W-4015	22800	16400	23.77	119¾	130
S-4016	15000	11000	W-4016	24000	17600	23.77	128	138¼
S-4017	15750	11750	W-4017	25200	18800	23.77	136¼	146½
S-4018	16375	12500	W-4018	26200	20000	23.77	144½	154¾
S-4019	17000	13250	W-4019	27200	21200	23.77	152¾	163
S-4020	17600	14000	W-4020	28160	22400	23.77	161	171¼
S-4021	18150	14750	W-4021	29040	23600	23.77	169¼	179½
S-4022	18650	15500	W-4022	29840	24800	23.77	177½	187¾
S-4023	19100	16250	W-4023	30560	26000	23.77	185¾	196
S-4024	19500	17000	W-4024	31200	27200	23.77	194	204¼

Capacities and Dimensions of Utica-Duplex SUPER-SMOKELESS Boilers

Number Steam	Steam Ratings, Sq. Ft. High Output	Steam Ratings, Sq. Ft. High Efficiency	Number Water	Water Ratings, Sq Ft. High Output	Water Ratings, Sq Ft. High Efficiency	Grate Area Sq. Ft.	Length of Sections Inches	Length of Sections and Smoke Box Inches
S-827	12750	8500	W-827	20400	13600	28.76	53¾	70¾
S-828	15000	10000	W-828	24000	16000	28.76	62	79
S-829	17250	11500	W-829	27600	18400	33.46	70¼	87¼
S-8210	19500	13000	W-8210	31200	20800	33.46	78½	95½
S-8211	21750	14500	W-8211	34800	23200	38.16	86¾	103¾
S-8212	24000	16000	W-8212	38400	25600	38.16	95	112
S-8213	25400	17500	W-8213	40640	28000	42.86	103¼	120¼
S-8214	27000	19000	W-8214	43200	30400	42.86	111½	128½
S-8215	28500	20500	W-8215	45600	32800	42.86	119¾	136¾
S-8216	30000	22000	W-8216	48000	35200	47.54	128	145
S-8217	31500	23500	W-8217	50400	37600	47.54	136¼	153¼
S-8218	32750	25000	W-8218	52400	40000	47.54	144½	161½

Height of water line: 24 series, 45½ inches; 33 series, 53 inches; 40 series, 57 inches; 82 series, 57 inches.

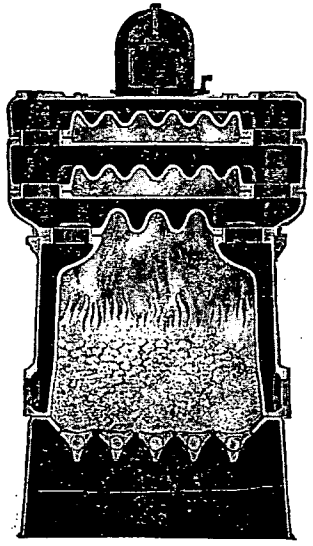
Equipment Shipped with Boilers

All SUPER-SMOKELESS Boilers are provided with equipment of the best type. Steam Boilers are equipped with Water Column with gauge glass and compression cocks; Retard Steam Gauge with Bourdon brass tube spring, Non-Glare Dial, syphon and cock; All-brass Pop Safety Valve, *A. S. M. E.* Standard; and Automatic All-metal Damper Regulator suitable for low pressure. Every boiler is furnished with a complete set of firing tools, consisting of shaker handle, hook, hoe, slice bar and flue brush with handle. Duplex Steam Boilers are equipped with Steam Header, Return Yoke, and Equalizer fitted with Hartford Connection which may be used or not, as desired.

Weil-McLain

SCIENTIFIC COMBUSTION BOILERS

WEIL-McLAIN COMPANY—Michigan City, Ind.—Chicago, Ill.



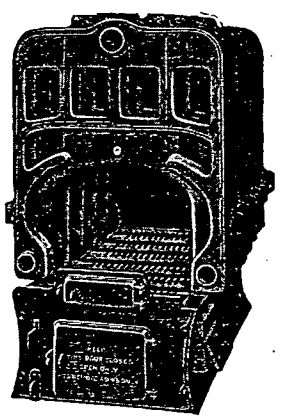
The Weil-McLain ROUND TYPE BOILER with its CORRUGATED FUEL-SAVING HEATING SURFACES and its long "back and forth" fire travel embraces the newest and best conceptions of heating engineers.

Other points of merit in the Weil-McLain Round Type Boiler are: fire-pot and crown sheet cast separately to permit easier handling; large fire door; handy front clean-out doors in every section and triangular type grates which cut and shake out all ordinary clinkers.

STEAM		WATER		Actual Diam. Grate and Fire Pot Inches (Both Steam and Hot Water)
Size Boiler	Rating Sq. Ft.	Size Boiler	Rating Sq. Ft.	
5-S-17	395	5-W-17	650	17
5-S-19	480	5-W-19	795	19
5-S-22	660	5-W-22	1090	22
5-S-25	865	5-W-25	1430	25
5-S-28	1065	5-W-28	1760	28
5-S-31	1350	5-W-31	2225	31
6-S-17	410	6-W-17	675	17
6-S-19	500	6-W-19	825	19
6-S-22	695	6-W-22	1145	22
6-S-25	915	6-W-25	1510	25
6-S-28	1130	6-W-28	1865	28
6-S-31	1425	6-W-31	2350	31

NOTE: Table is not complete; these boilers are also made four section.

The Weil-McLain SECTIONAL or SQUARE TYPE BOILER like the Round Type has corrugated heating surfaces directly above the fire, has a long "back and forth" fire travel—features that add greatly to the efficiency and economy of this boiler.



WATER				STEAM				Grate Area Sq. Ft. (Steam and Water)
Number	Water Rating Sq. Ft.	Total Length Inches	Grate Area Sq. Ft.	Number	Steam Rating Sq. Ft.	Total Length Inches	Water Line Inches	
22-W-5	1500	51	4.88	22-S-5	900	51	46	4.88
22-W-6	1825	58	5.96	22-S-6	1100	58	46	5.96
22-W-7	2150	65	7.03	22-S-7	1300	65	46	7.03
25-W-5	1825	51	5.70	25-S-5	1100	51	51	5.70
25-W-6	2225	58	6.90	25-S-6	1350	58	51	6.90
25-W-7	2650	65	8.10	25-S-7	1600	65	51	8.10
25-W-8	3050	72	9.30	25-S-8	1850	72	51	9.30
28-W-5	2700	63	7.97	28-S-5	1650	63	55	7.97
28-W-6	3275	72	9.72	28-S-6	2000	72	55	9.72
28-W-7	3850	81	11.47	28-S-7	2350	81	55	11.47
28-W-8	4425	90	13.22	28-S-8	2700	90	55	13.22
36-W-5	3850	66	10.25	36-S-5	2350	66	58	10.25
36-W-6	4725	75	12.50	36-S-6	2875	75	58	12.50
36-W-7	5600	84	14.75	36-S-7	3400	84	58	14.75
36-W-8	6475	93	17.00	36-S-8	3925	93	58	17.00
36-W-9	7350	102	19.25	36-S-9	4450	102	58	19.25

NOTE: Table is not complete; this type boiler is also made in a 48" size.

McDonnell & Miller

General Offices:
Wrigley Building
CHICAGO

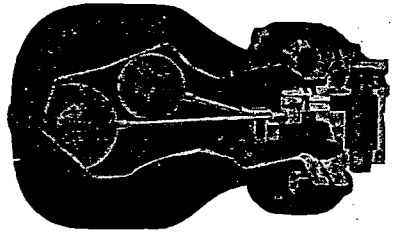
Eastern Warehouse
Stock
Bush Terminal, N. Y.

"Doing One Thing Well"

PRODUCTS:

Duplex Water Feeders
Duplex Switches

McDONNELL & MILLER DUPLEX WATER FEEDERS

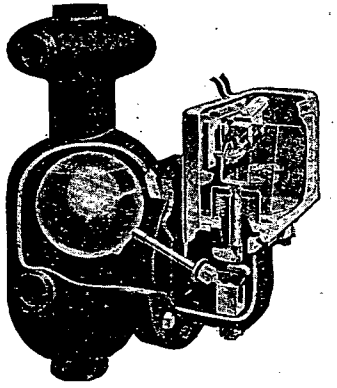


The McDonnell & Miller Duplex Water Feeder is a simple and positive means of controlling the water line in low-pressure steam boilers, automatically supplying make-up water as necessary, and protecting the boiler against flooding by disposing of any excess condensate that may be returned from the system.

It is completely self-contained. Steam and water equalizing connections as well as supply and overflow connections, are all made in the head so that floats and valves may be exposed for inspection without breaking a single pipe connection.

May be applied to all steam heating systems whose pressure does not exceed 15 pounds and are suitable for city water pressures up to 115 pounds. Weight, packed for shipment, 50 pounds.

McDONNELL & MILLER DUPLEX SWITCH



The **McDonnell & Miller Duplex Switch** is a combination Low Water Cut-off and Pressurestat for oil fired boilers.

When the boiler water line falls to the bottom of the gauge glass the switch cuts out the oil burner motor and cuts it in again when there is at least one inch of water in the glass.

The pressurestat may be adjusted for any cut-out pressure from 9 ounces to 10 pounds 6 ounces and the difference between cut-out and cut-in pressures may be varied at will from 7 ounces to 5 pounds 6 ounces.

The switch movement is springless being operated on the weight-and-lever principle. It is permanent and accurate in its adjustment and may be easily adjusted without tools.

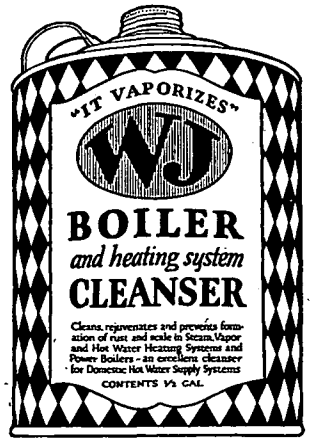
The **Duplex Switch** is easily installed in the gauge column in less than an hour. Weight, packed for shipment, 25 pounds.

NO RAD RUST CORP.
Manufacturers
Dept. A 1
Lancaster, Pa.

"IT VAPORIZES" WJ

JOHN G. KELLY
Exclusive Distributors
210 East 45th Street
New York City

BOILER AND HEATING SYSTEM CLEANSER



W. J. BOILER AND HEATING SYSTEM CLEANSER when heated actually vaporizes and therefore can circulate through the entire system—the pipes, radiators, valves, and traps, BESIDES the boiler. It so thoroughly cleans the entire system of oil, grease, core-sand, rust, and scale, that it will, PERMANENTLY cure priming, surging, and sluggishness. It is also a wonderful tonic for old systems as a cure for slow-steaming.

A Harmless Liquid

containing neither acid nor poison. It will not bake or harden in the system. It contains no sediment to clog up the system.

Very Simple To Apply

being poured into the boiler through the safety valve opening. Then get up a pressure; W. J. vaporizes and cleanses. After sufficient time has elapsed the mucky water is drawn from the bottom draw-off cock and you still have enough of the liquid left in the boiler to prevent rust and scale from forming for a year.

GUARANTEED to cleanse the system thoroughly and increase its heating efficiency.

Successful as evidenced by the following testimonials

PAUL R. ALLEN,
New York Architect, says:

"The two dead radiators, to which I called Mr. Howett's particular attention, are now apparently 100 per cent efficient, a fact undoubtedly due to the peculiar rust and grease eliminating properties of your product.

"My entire plant has been greatly benefitted and water now drawn from the bottom of the boiler is quite clear and free from all grease, scum, sediment, etc.

"I am convinced that this method is the correct one and the only sure means of securing a thoroughly clean plant. I will not hesitate to recommend its use, with the utmost confidence in its success."

H. W. REIS, Vice-President of W. A. Russell & Co., says:

"At the time of putting in the W. J. 16, the builder of my home assured me that the heating system had been thoroughly cleaned out and 'blown' off within the last year and that he was sure there was no oil, rust, grease, etc., in the system.

"The results obtained from W. J. 16 were truly remarkable—not only did I draw off more than a quart of thick brown oily substance, but I was able to get up steam very readily and thereby eliminate the discomforture that we had been encountering during the entire winter. I also noted after the system was thoroughly cleansed that there was considerable saving in fuel in addition to having a steady uniform heat.

"I have recommended W. J. 16 to a number of my neighbors who have obtained the same gratifying results, and in conclusion, beg to state that it is impossible to determine the real merit and economy of W. J. 16, until you have actually used it."

VAPOR ENGINEERING CO., says:

"In another case, a residence at 156 East 78th Street, New York City, we found though the boiler had been blown down, in the usual manner, that the owners complained that they could not obtain heat in all the radiators without an excessive fire at the boiler. We put one gallon of W. J. Boiler and Heating System in the Veco Governor which permitted its free entrance into the boiler and on the following day we took out of the boiler at least two quarts of oil, sample of which we have here at the office. After taking the oil from the boiler 2-ounce pressure was raised on the boiler in about three minutes time and every radiator in the building was heated all the way through. Since that, the owner has called this office and advised that the plant had been improved 100 per cent. We shall be glad to furnish the name of this job, or any of the others that we have tested, should anyone be interested.

"We are convinced that your preparation will save both the owner and the heating contractor quite a little time and money and for that reason are going to include it in all of our future specifications."

C. A. DUNHAM CO., says:

"We used the cleanser according to your instructions, and are pleased to report that it was very effective in cleaning the dirt out of the system.

"Thanking you very much for sending us this cleanser, and assuring you that we will tell everyone who is having boiler trouble about it, we are"

H. A. YATES ENGINEERING CO., Inc., says:

"On the one job which we used this cleanser, it worked out very well indeed, cleaning the system thoroughly, steadying the water line which formerly had been jumping, and decreasing the time which it formerly took to raise pressure on the system.

"We like it so well that in the future on our blow down jobs, of which we have forty or fifty a year, we intend to use it exclusively."

RUSH, LEE & RUSH, St. Louis Architects and Engineers, say:

"We have used your W. J. Boiler and Heating System Cleanser in our building and find it to be very effective in cleansing the water in the boiler in fact consider it superior in every respect."

A. S. GRANT, Sales Manager of ABENDROTH BROS., says:

"I put this liquid in the heater in my house and it certainly took out the oil and dirt from the heating system, and showed a vast improvement by getting up steam more quickly. One evening after arriving home, my wife advised me that the steam gauge showed ten lbs. pressure early in the evening and wanted to know if the safety valve was in working order as she became quite frightened. I asked her why she allowed the steam to come so high and she said that since I used the cleanser, it was hard to keep down the steam.

"I certainly recommend this compound for any new or old job in both steam or vapor."

The Vinco Company, Inc.

75 Vesey Street, NEW YORK CITY

Vinco treatment for "breaking in" new or remodeled steam and vapor heating systems

TELEPHONE—Cortlandt 1995 CABLE ADDRESS—Vincomp, New York



Vinco (Latin "I conquer") is a simple, safe, sure cleanser —a necessary corrective which establishes and maintains free, easy circulation, uniform heat distribution and high fuel economy.

Vinco stops foaming, priming, surging, sluggish steaming, clicking of pipes, incomplete circulation and poor radiation by removing oil, grease, scale and dirt from the internal surfaces.

Vinco does not temporarily disguise or blanket the foaming, but **permanently** removes causes as well as effects, and does this completely, without blowing down under steam, without harm to any part and at a cost of about one cent per sq. ft. of radiation for the **Vinco** compound.

Using **Vinco** for initial "breaking in" gives the system a clean bill of health from the start by assuring positively that the internal surfaces are and will remain clean, and later is a protection against the cracking of boiler sections that often results from priming and slugs of cold returns. Treatment with **Vinco** quickly develops the best performance permitted by the design and avoids the shaken confidence and complaints which often result in disputes and withheld final payments. **Vinco** also saves the heating contractor many non-productive hours, by doing its work thoroughly without "come backs."

Specification

Cleaning the System: Upon completion of the installation, the contractor shall clean the system by the **Vinco** Method to remove all 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 to	4600	square feet of	*radiation	28	"
4601 "	5000	" "	"	30	"

above 5000 square feet use an additional pound of **Vinco** each additional 300 square feet of radiation.

*All radiation should be taken at actual rating.

Adding a little **Vinco** each heating season keeps all internal surfaces constantly clean.

Vinco Results are Guaranteed

Vinco is guaranteed to meet every claim and to contain no potash, lye, soda, oil, acid or other harmful ingredients. Results must be satisfactory or purchase price will be refunded.

Patents are pending upon the product, the process of manufacture and methods of application. The use of any unlawful imitation will be subject to prosecution. For safety and full benefits, specify by name and see that the material comes from 3-lb., 5-lb., or 10-lb. lithographed cans bearing name and registered trademark as shown.



Price $1.50 per lb. with liberal discount to the trade.

Write for Literature

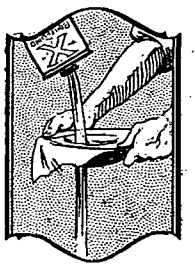
"X" LIQUID

REPAIRS LEAKS IN STEAM AND HOT WATER HEATING SYSTEMS, HIGH AND LOW PRESSURE BOILERS

"X" LABORATORIES,

25 West 45th St., New York, N. Y.

Factories: Boston and Toronto



"X" Liquid can be poured thru a cloth. Therefore it cannot clog. It is harmless to all metals, rubber and leather

"X" Liquid is a collodial solution which repairs leaks quickly and permanently in high and low pressure boilers and hot water heating systems below the water line without shutting down. Just pour "X" in. "X" Liquid circulates freely with the water in the system, trickling out through the leaks, becoming a solid by contact with the air and heat, and contracts and expands with the metal.

"X" Liquid seals cracked and porous castings, leaky bolt heads, split nipples, leaking joints and all leaks inside the system which otherwise would be impossible to get at.

"X" Liquid is in practically world-wide use, it being also used to repair leaking automobile and aeroplane radiators, cylinders and water jackets. "X" is used to repair leaks in all places where hot water is confined.

"X" Liquid has been used for years by the Standard Oil, General Electric, American Tel. & Tel., etc., and by the U. S. Government on ALL aeroplane endurance flights from the Trans-Atlantic Flight in 1922 to the MacMillan Arctic Expedition in 1925.

"X" Liquid increases boiler efficiency because it prevents rust and the deposits of lime and silica which quickly coat the inside of pipes and boilers, reducing heat conductivity. Boilers can be kept permanently free from corrosion by the occasional addition of "X" Liquid to the water.

An "X" repair is a permanent repair and will withstand over 600 lb. pressure.



"X" BOILER LIQUID

SIZES AND PRICES

Carried by all Jobbers of Steamfitters Supplies. Sold on a money back guarantee.

Quart Cans..... $6.00 Each
Half Gallon Cans..... $10.00 Each

The American Nokol Co.

215 North Michigan Ave., CHICAGO, ILL.

Facts about

THE NEW *Silent* NO COAL NOKOL

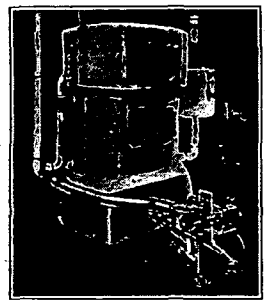
Automatic Oil Heating for Homes

Fully automatic oil heat—for residences and other buildings—large or small

General Description.—Nokol was the first automatic oil burner practical for heating homes—perfected 9 years ago. It provides fully automatic heat—temperatures with maximum variation of 2 deg., thermostat control. Atomization is by combination of Venturi and nozzle—suction provided by blower fan, motor driven. Combustion is also markedly efficient (see below).

Combustion.—Since oil can only burn completely in high temperature zones, Nokol has a combustion chamber independent of furnace or boiler. By this means necessary temperatures for complete, clean combustion almost instantly reached—and maintained.

Cost.—In more than 29,000 homes—for periods up to 9 years—Nokol heating costs have been found no higher than for hard-coal; usually less. The **lowest-cost,** fully automatic oil heat **known.**



Typical Nokol Installation, heating 14-room house, Chicago, Ill.

Efficiency.—Orsat tests show an average of 12 per cent carbon dioxide in flue gas—almost instantaneously after starting, and during whole period of Nokol operation. This indicates combustion efficiency of at least 85 per cent.

Ignition.—Nokol has either gas or remarkably efficient electric ignition—the latter for use where gas is not available. The gas "pilot" light is constantly ready for operation. Expanded momentarily as combustion begins and ends—to avoid puffing out.

Noise.—The new Silent Nokol—by simple, effective softening of flame—cuts noise to the vanishing point.

Safety.—Nokol was the first domestic oil burner listed as standard by The Underwriters' Laboratories; approved by all leading safety boards. Equipped with double safety controls—positive in character.

Sizes.—Any furnace or boiler may be fitted with Nokol, which is one of the few automatic oil burners made in adequate range of sizes.

SENT UPON REQUEST

A concise file of data on Nokol—covering every question of installation and operation—sent upon request. It is in convenient form for reference and filing.

Automatic Burner Corporation

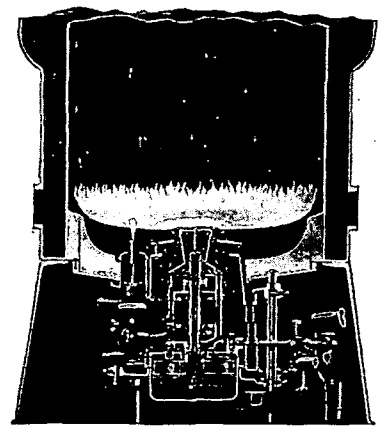
312 North May Street - - CHICAGO, ILL.

How ABC Heats

Your thermostat, placed in one of your living rooms, is set at 70 deg. The temperature in your home drops to 68 deg.—automatically ABC starts.

The lowering of the oil in the burner reservoir drops the float, unseating the three check balls. As the oil flows in from the wall float, which holds one pint of oil, the lowering of the float in its container automatically starts the pump. The pump draws oil from an underground tank.

When enough oil has been admitted into the reservoir the dependable three balls set, stopping



the automatic pump and checking the flow of oil. Observe this: At no time do you have more than one quart of oil in your basement.

The armature shaft by centrifugal force draws the oil through a taper hole up to the atomizing cup. Air is taken in—always the proper amount—through holes in the bottom of the cup.

The oil and air, thoroughly mixed and broken up, are thrown into the boiler, noiselessly, as a fine atomized, instantly inflammable mist. Ignited by the pilot light, the mist of oil burns with a clean, soft flame of circular form.

Twelve Reasons Why A B C Appeals to Engineers

1. **Converts coal boiler into oil burning boiler:** ABC is designed so that it retains the natural functions of a coal heating boiler. All boilers were designed to burn coal—and not to absorb heat traveling at a high velocity. The ABC horizontal circular flame heats from the grate on the water legs. Result: quick heat; low stack temperature; saving in oil.
2. **Oil burned in suspension:** This is the first law of efficient oil burning.
3. **Longer boiler life:** Burners with a concentrated flame in time destroy a boiler. The ABC circular flame, evenly applied all around the boiler, adds to its life.
4. **No carbon or soot:** Engineers know what an immense advantage this is.
5. **No fan or blower:** Heat is not forced up the chimney and wasted.
6. **Less oil required:** Unique means of atomization assures complete combustion. Every particle of oil is burned. The heat rises slowly and is maximumly absorbed by the boiler.
7. **Simple:** The life and amount of service of a piece of machinery is in ratio to the number of moving parts. ABC has only one moving part subject to wear. It is simple. It has no complicated or delicate adjustments.
8. **Burns low-priced oils:** 32–36 gravity oil is recommended.
9. **Odorless:** An ABC heated home is odorless.
10. **No unsightly parts outside of boiler:** The burner is entirely enclosed in the boiler out of the way.
11. **Automatic:** Heat when you want it—as you want it.
12. **Quiet:** The importance of quietness in a domestic oil burner cannot be overestimated. ABC is really quiet.

Full Information will be Sent You Gladly

No.	Maximum Steam Radiation	Max. Hot Water Radiation	Approximate Floor Space Required	Shipping Weight	Price
Type E	3000	4500	Enclosed in Boiler	110 lbs.	$600 to $1,000

ABC OIL BURNER

no noise - no carbon

Ballard Oil Equipment Co.

Oil Burning Engineers and Contractors

NEW YORK WASHINGTON PHILADELPHIA NEWARK

And Agencies Throughout the United States

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.



Installation of Ballard Type H Rotary Mechanical Burners in two 150-H. P. Simplex Boilers

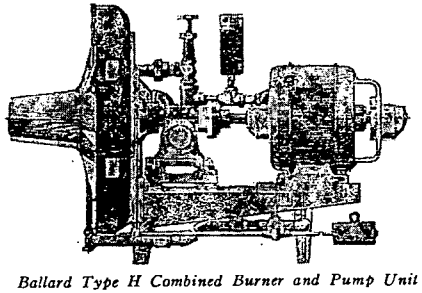


Ballard Type A, Automatic Oil Burning System Installed in Heating Boiler and Hot Water Heater

Ballard equipment includes: high pressure mechanical burners, steam atomizing burners, the Ballard Type H rotary low pressure mechanical burner for fuel of 12-16 degrees Baume, the Ballard Type H rotary low pressure mechanical burner and pump unit combined for fuel of 24 degrees Baume and higher, the Ballard Type A automatic domestic and semi-industrial system, and automatic residence systems. Descriptive literature sent upon request.

Ballard Service

Recognized the World Over



Ballard Type H Combined Burner and Pump Unit

Factory Branch Offices:
SAN FRANCISCO
SACRAMENTO
PHILADELPHIA

S. T. JOHNSON CO.

——OIL BURNERS——

Trade Mark Registered

Distributors and Dealers Throughout the United States and in Foreign Countries

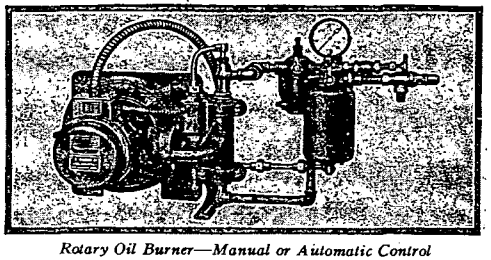
Main Office and Factory: 940-950 Arlington Avenue
Oakland, California

Twenty-one Years of Specialization in Oil Burning Equipment

Products

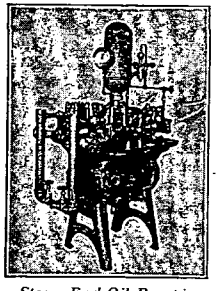
A full line of oil burning equipment, with a type and size for every heating and power purpose.

Rotary Oil Burners, manual or full automatic control. Five sizes—600 to 20,000 sq. ft. steam radiation. Successfully used in all kinds of boilers, using fuel oil from 14 to 34 deg. Baume. Efficient built-in oil pump, drawing from underground tank. Listed as standard by Underwriters' Laboratories, an organization established and maintained by the National Board of Fire Underwriters.



Rotary Oil Burner—Manual or Automatic Control

Low Pressure Air Burners and Equipment.—For any kind of oil. Unusual efficiency, economy, simplicity. Designed to vaporize heavy crude fuel oil with air pressure one to five pounds per square inch. Especially recommended for large installations.



Steam Fuel-Oil Pumping Equipment

Whirlwind Burners.—Easily adapted to any furnace, boiler or oven. Two styles and six sizes—500 to 4,000 sq. ft. steam radiation; 5 to 40 horsepower. Can be safely operated with gravity oil supply. Recommended only for small boilers.

Steam Fuel Oil Pumping Equipment.—Consists of duplex steam-driven oil pumps, mounted in duplicate upon cast-iron drip pan over heater, with legs. Also furnished with one pump. Equipment ranges from 20 to 2,000 horsepower. Recommended for large installations.

Fuel-Oil Pumps.—Electric motor-driven oil pump—a simple device to pump any grade fuel oil or distillate from underground oil supply tank and to maintain pressure on oil-supply piping to one or more Whirlwind Burners.

Long life and dependability characterize S. T. Johnson Co. equipment. Best materials and precision methods of manufacture. Correct design based upon proven engineering principles, developed during twenty-one years of successful manufacturing. Special literature furnished on request.

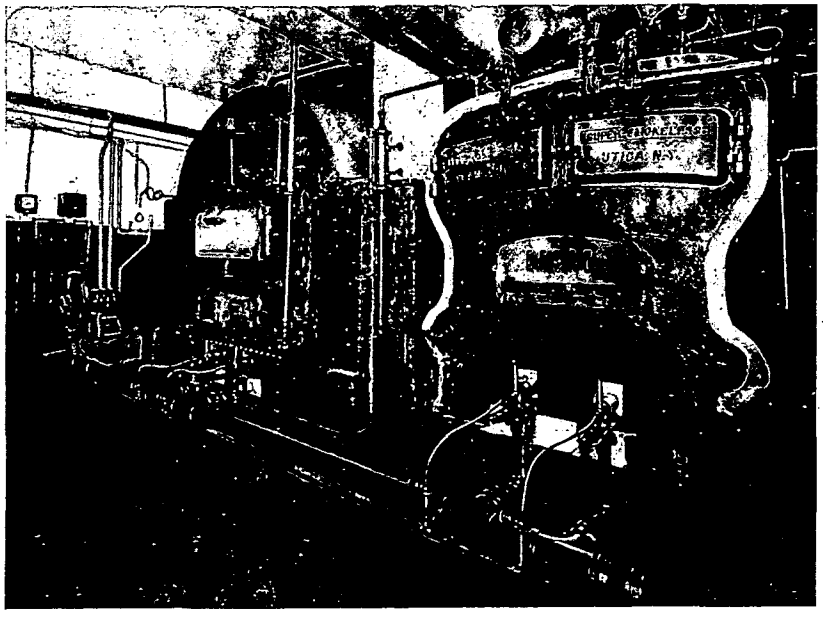


Steam Atomizing Burner

Winslow Boiler & Engineering Co.

Builders of Oil Burners

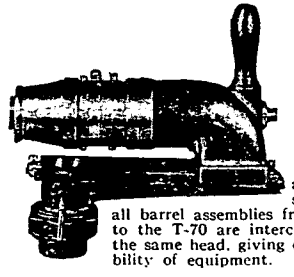
NEW YORK	CHICAGO	Factory GALESBURG
Show Room: 46 E. 41st St.	208 S. La Salle St.	Illinois



THE WINSLOW INDUSTRIAL BURNER burns efficiently all fuel oils from 14° Mexican Crude up.

The motor blower unit may be located at any convenient point near the boilers and connected to the burner assembly, in front of the boilers, by oil and air piping of correctly proportioned sizes.

The motor blower unit has a high grade gear pump that pulls the oil from the storage tank and delivers it at from 7 lbs. to 10 lbs. pressure to the burners. At the same time the blower is supplying the required air at low pressure, measured in ounces, to effect a thorough atomization of the oil. This unit is complete with a strainer, pressure gauge, check valve and oil relief valve.



Sliding Type

The burner as shown is standard and all barrel assemblies from the T-10 to the T-70 are interchangeable on the same head, giving extreme flexibility of equipment.

Single motor blower units handle a variety of burner assemblies and where dual units are twinned the capacities are not only doubled but the plant is insured against any shut down. There are several sizes of motor blower units and also of burners.

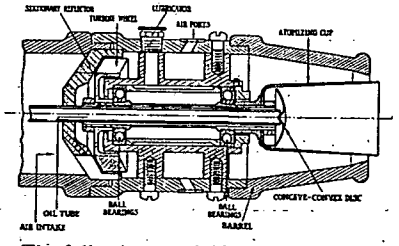
In specifying burners determine whether the boilers are to carry an overload. Ordinarily, steel boilers can be provided with burners rated at the boiler rating unless overloads are contemplated. On the other hand, cast iron boilers can usually be provided with burners rated at about 70 per cent of the boiler rating. This is due to the different methods of rating steel and cast iron boilers.

Wherever possible specify two smaller burner nozzles even though one larger one will do the work, so as to assure an easier control of fuel consumption. In nearly all boilers, two burners, by giving a wider flame distribution, reduce excess air, assuring better combustion. At the same time by utilizing more of the heating surface, the efficiency is still further increased. Where loads are apt to be variable the double burner nozzle is ideal.



The cut to the right above shows the method of attaining atomization. The oil travels down the central tube and impinges onto the concave-convex rotating disc. It whirls centrifugally to the edge of the disc and strikes the heel of the revolving cup in a thin film. It then travels along the inner wall of the cup to the rim where it is whirled off at tremendous speed, mixing with the air from the barrel and entering the boiler perfectly atomized.

The cut to the left shows the balanced rotating cup and revolving turbine wheel. Two sets of ball bearings between these units insure low frictional resistance and high speeds.



The following partial list of WINSLOW BURNER assemblages will be of assistance in determining correct sizes for a large scope of work. The ratings in column five are based on 100 square feet of steam radiation per horse power and represent the total load the burners can handle.

WINSLOW BLOWER AND BURNER CAPACITY

Motor Blower Unit	Size and Number of Burners	Maximum Steam Radiation	Motor Horsepower	Oil Pump Gallons per Minute	Air Outlet
B-60	1 T-10	3,500	¾	1½	2
B-60	2 T-10	5,000	¾	1½	2
B-60	1 T-30	5,000	¾	1½	2
B-60	2 T-30	7,500	¾	1½	2
B-60	1 T-40	6,500	¾	1½	2
B-90	3 T-10	9,500	1½	1½	2
B-90	3 T-30	11,000	1½	1½	2
B-90	2 T-30	10,000	1½	1½	2
B-90	2 T-40	12,000	1½	1½	2
B-120	4 T-10	11,000	2	1½	2
B-120	3 T-30	14,000	2	1½	2
B-120	2 T-40	16,000	2	1½	2
B-120	1 T-70	10,000	2	1½	2
B-180	5 T-10	14,000	3	3	2½
B-180	4 T-30	20,000	3	3	2½
B-180	3 T-40	22,000	3	3	2½
B-180	2 T-70	22,000	5	3	2½
B-300	8 T-10	20,000	5	3	3
B-300	6 T-30	24,000	5	3	3
B-300	5 T-40	30,000	5	3	3
B-300	4 T-70	34,000	5	3	3
B-500	1 T-250	25,000	5	3½	5
B-500	2 T-250	50,000	5	3½	5

In addition to the WINSLOW INDUSTRIAL burner described here the Winslow Boiler & Engineering Company manufactures a complete line of fully automatic, residential and apartment house burners.

The gas and the electric ignition KLEEN-HEET burners, with the vacuum oil feed eliminating the usual basement auxiliary tank, are built in a total of nine sizes and are thus suitable for a great range of work.

The Junior KLEEN-HEET burners, without the vacuum feed but completely automatic in operation, are in two sizes. The No. 10 is rated at one thousand feet hot water and is suitable for the average home. The No. 6 is especially adapted to Arcolas and small domestic water heaters.

Inquiries to the INDUSTRIAL DIVISION of the WINSLOW BOILER AND ENGINEERING COMPANY, 208 South La Salle Street, Chicago, Illinois, will be promptly answered.

TRANE HEAT CABINETS

(See Trane Heating Specialties on pages 530 and 531. Also Trane Pumps on pages 474 and 475.)

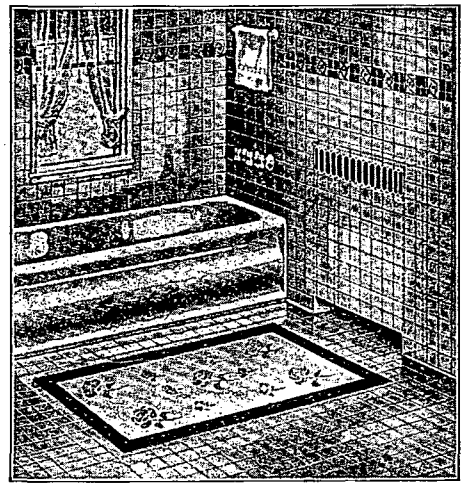
The Trane Company

La Crosse, Wis.

BRANCH OFFICES

New York, Chicago, Boston, Cincinnati, Newark, Philadelphia, Buffalo, Cleveland, Detroit, Seattle, Los Angeles, Albany, Minneapolis, Salt Lake City, Greensboro, N. C., Zanesville, Ohio, Tampa, Fla., Baltimore, Md., Des Moines, Iowa, New Haven, Conn., Sheboygan, Wis., Kansas City, Mo.; ENGLAND: 22-23 Clerkenwell Close, London, E. C. 1. CANADA: The Trane Co., 21-23 River St., Toronto, 2; Thomas Robertson & Co.; 134 Craig St., West, Montreal, F. S. Murdoch, 310 Breadalbane, Winnipeg; A. B. Madden, 48 Sparks St., Ottawa. JAPAN: Mitsubishi Shoji Kaisha, Ltd., Tokyo. CHINA: C. J. Doughty & Co., 8-9-10 Brenan Road, Shanghai.

The Trane Systems of Vapor and Vacuum Heating, Patented Heating Specialties, Trane Heat Cabinets, and Trane Automatic Electric Pumps, For All Purposes



The Trane Heat Cabinet is essentially a heating element enclosed in a cabinet that acts as a chimney.

The heating element or Heater, as shown by the illustration on the next page, occupies a comparatively small space in the bottom of the cabinet.

It is designed in such a way that unless air is passing over it, the Heater gives off very little heat. But when air around the Heater is allowed to circulate, heat is given off very rapidly.

HEAT CABINET FEATURES

Trane Heat Cabinets can be used wherever an ordinary cast-iron radiator can be used—and in many places where it can't.

Economy of Fuel.—Heat Cabinets save fuel.

Light Weight.—One radiator weighs as much as five Heat Cabinets. In other words, enough Heat Cabinets to heat an ordinary house do not weigh any more than about two radiators. Think what this means in freight saving.

Low Cost.—A Heat Cabinet, although its heat unit is constructed of brass and copper, does not cost as much as a radiator and shield.

Small Space.—Heat Cabinets use much less space than enclosed radiators.

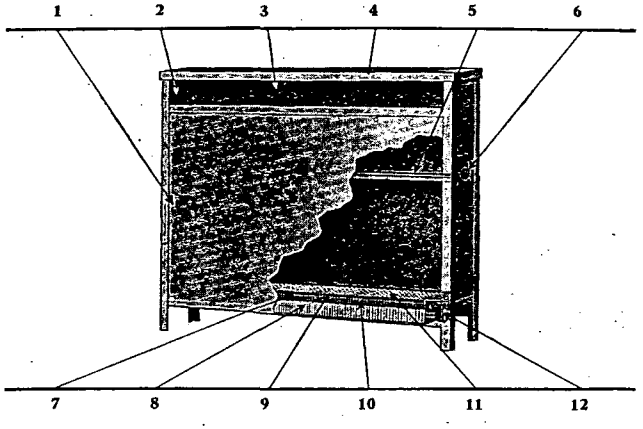
Beauty.—Heat Cabinets are furniture, and can be finished to match any surroundings.

Concealed When Desired.—Heat Cabinets can be built into the walls, so nothing is visible except the heat outlet.

Temperature Control.—Heat Cabinets give to all present forms of radiator heating. INCLUDING hot water systems, the feature of temperature control at each heat outlet—exact, and instantaneous.

Quick Heat.—The heating of all present types of radiator systems is much faster with the use of Heat Cabinets—especially hot water systems, where heating is accelerated 300 per cent to 400 per cent.

Permanence.—Heat Cabinets are solid and rigid, with no joints or seams—as permanent as the piping.



1. Cabinet made of strongly reinforced sheet metal, painted with one priming coat. Can be used this way, or refinished as desired to match any surroundings.

2. The heat outlet. Grille not necessary, and not furnished as standard equipment, but can be added if desired for artistic reasons.

3. All heat from Cabinet is thrown to the front, thus keeping walls clean, and leaving top of cabinet free for the placing of ornaments, etc., without decreasing the efficiency of the Cabinet.

4. Cabinets furnished with or without tops, as desired, thus enabling owner or architect to keep the Heat Cabinets in harmony with woodwork and furnishings of the room. Tops furnished by us are made of metal.

5. Heat control damper. By simply regulating the position of this damper, perfect control of heat is secured on all types of modern heating systems, including hot water and one-pipe steam.

6. Heat control knob. This knob is placed on the ends of the cabinets where visible cabinets are used. On the concealed or recessed type cabinets, the damper arrangement is included in a grille.

7. The Heater of a Trane Heat Cabinet. This unit is made up of copper sheets fastened by a patented process to a U-pipe, through which the steam or hot water passes.

8. Copper sheets in heater are at nearly the same temperature as the U-pipe, giving a large area of heating surface in a very small space.

9. Air entering at bottom of Heat Cabinet, passing over the heated copper sheets and up through the outlet, gains great velocity and therefore heats the room rapidly.

10. Heating unit is rigidly constructed, and is built to last forever. It is not fastened to the Cabinet. Cabinet can be removed at any time.

11. Different capacities in heating units are secured by varying the length of the unit. Capacity also increases with increased height of the Cabinets.

12. Inlet and outlet are at same end of heating unit. Exact connections at this point vary with different types of heating systems, but heating units are always the same.

The Herman Nelson Corporation

Moline, Illinois

BRANCH SALES AND SERVICE OFFICES

Belfast, Me.	Philadelphia	Chicago	Des Moines	Emporia	Spokane
Boston	Scranton	Cleveland	Milwaukee	Omaha	Portland
New Haven	Pittsburgh	Columbus	Minneapolis	Kansas City	Seattle
New York City	Grand Rapids	Toledo	St. Louis	Denver	Vancouver
Syracuse	Detroit	Indianapolis	San Francisco	Salt Lake City	Toronto

PRODUCT—Herman Nelson Invisible Radiator.

The Herman Nelson Invisible Radiator is so designed as to be completely concealed and truly invisible in any standard wall or partition as is shown in the accompanying illustration.

The Radiator itself is a single unit consisting of a special cast aluminum core acting as a steam container and a plurality of copper plates mounted on the core and acting as heating surface. The heat in the steam is transferred to the inner surface of the core, diffused through the metal and delivered from the outer surface of the copper plates to the surrounding air. Built of indestructible materials without joints, it will not wear out, rust, leak or burst.

The Herman Nelson Invisible Radiator is furnished as a complete unit. The Radiator being enclosed in a substantial steel cabinet having a cold air inlet opening at the base and a hot air outlet grille with damper at the top. The complete unit is designed to be placed in a wall or partition, covered with metal lath and plastered so that nothing will show but a neat opening at the bottom and the outlet grille at the top.

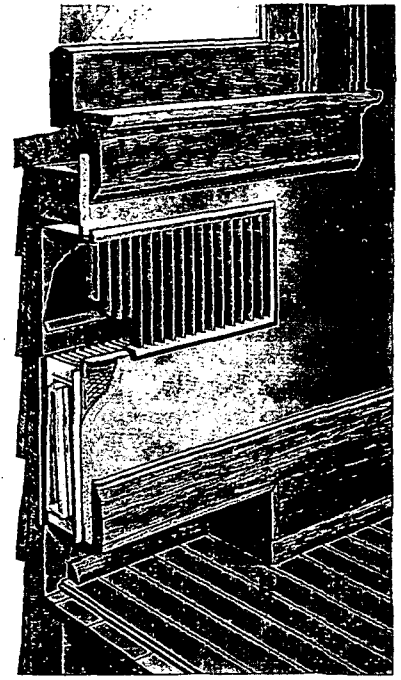
The installation of **The Herman Nelson Invisible Radiator** involves no radical change in plan. The complete unit is made 3⅝" deep to correspond with usual framing materials. The only preparation necessary is to provide pockets in the walls of the proper width and height to receive the unit. In masonry walls, however, bucks or some other suitable means should be provided for securing wire lath.

The Herman Nelson Invisible Radiator is made in four sizes governed by the length of Radiator and designated nominally as 20", 30", 40" and 50". Also, each length of Radiator is regularly enclosed in two standard heights of cabinets, one of minimum height 20¾" designed to fit under the average window, and the other 88" high designed for use on blank wall where higher outlet is desired. Units can also be arranged for any special height of outlet above the minimum on special order at additional cost.

Various units are obtainable ranging in capacities of from 16 to 84 sq. ft. of direct radiation equivalent.

The Herman Nelson Invisible Radiator may be used with any type of steam, vacuum or vapor heating systems.

A beautifully illustrated catalogue together with complete technical data will be furnished you on request to our main office at Moline, Illinois.



(See also page 419, Unit Heater Section.)

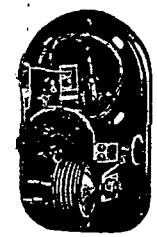
ABSOLUTE CON-TAC-TOR CORPORATION

ELKHART, INDIANA

Originators of Non-Deteriorating Mercury Switches



The **CON-TAC-TOR Mercury Switch** has made the Automatic High Voltage Control possible. Switching Motors without a Relay was unknown before the **Mercury Switch** was used for this purpose. Now thousands of fractional H. P. Motors are switched on all types of service without relays and are controlled on either Temperature or Pressure changes as desired.



No. 64

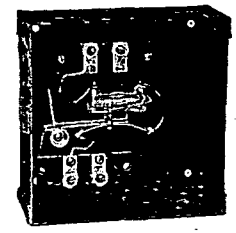
A few **CON-TAC-TOR Controls** are listed below.

Thermoswitch for Room Temperature Control—Mounted on Wall and Switches ¼ H. P. Motor without a relay.

BOILER CONTROLS

A complete line—Safety Controls for Oil Burners. *Primary Controls for Forced Draft Coal Installations.*

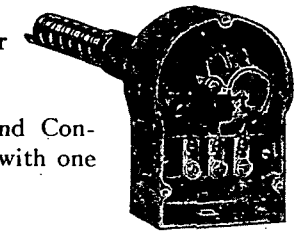
No. 33 **Pressureswitch** for Steam
No. 42 **Vaporswitch** for Vapor Systems.
No. 56 **Aquaswitch** for Hot Water.
No. 68 **Furnaceswitch** for Hot Air.
No. 59 **Bipass Gas Valve** for Pilot Light.
No. 80 **Shutoff Oil Valve** for Oil Line.



No. 98

Safety Controls for OIL BURNERS

Thermal Safety and Control on the Ignition with one moving part.



No. 48c

Lewis M. Ellison

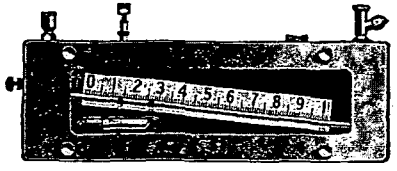
214 West Kinzie Street -:- CHICAGO, ILL.

ELLISON DRAFT GAGES — The Entering Wedge To Boiler Room Efficiency

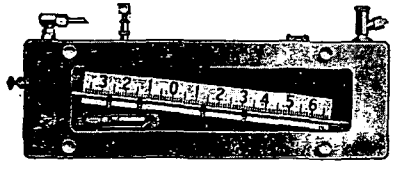
Ellison Draft Gages —The famous Ellison Inclined Tube Gage, the recognized standard of accuracy, was designed and introduced in 1896 by Lewis M. Ellison. Water in glass tubes having a variable movement, an oil of constant response for the indicating liquid was adopted—permanency of calibration established. Today there is an Ellison draft gage for every draft from the small domestic furnace to the super-power boiler, for traveling engineers and for technical institutions.

The gages have sliding scales for setting zero, requiring no refilling for several years. The stationary gages are black finished, of heavy construction, with white enameled scales, readings visible across the boiler room.

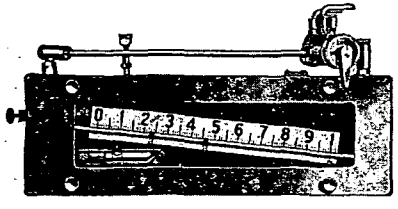
Bulletin of complete line on request



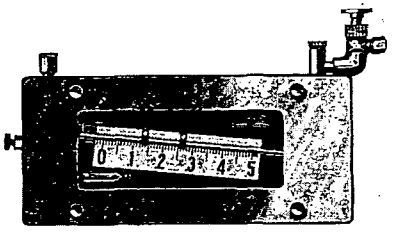
SINGLE-TUBE INCLINED: *This gage, for power boilers, is made in 1, 1½, 2, 3, 4, 5, 6, 7½ inches scale range, suction or pressure.*



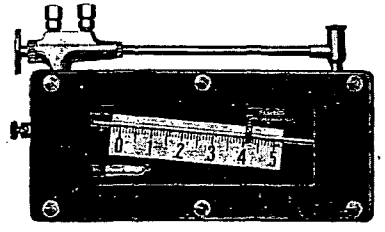
COMPOUND INCLINED: *This gage reads furnace draft to left, flue draft or differential to right of zero.*



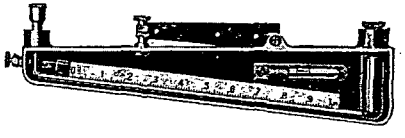
COMBINATION INCLINED: *By turning the handle of the cock, this gage reads furnace draft, flue draft or differential, 1, 1½ inch range.*



SINGLE-TUBE INCLINED: *This gage is for small boilers and furnaces, and for power boilers with operating draft not over the scale range of ½ inch. It is equipped with seal for 400 feet chimney height, natural draft.*



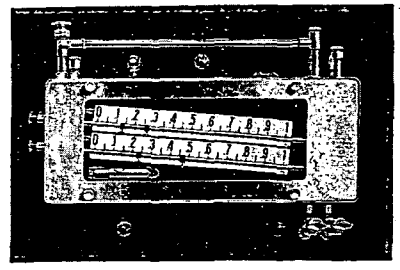
AIR FILTER GAGE: *This gage indicates the differential in hand air cleaning filters, piped from the inlet and outlet sides, complete with connections and casing inserts. Pointer is set for the highest permissible increase in differential for properly filtering the air—the most satisfactory and efficient filter gage known.*



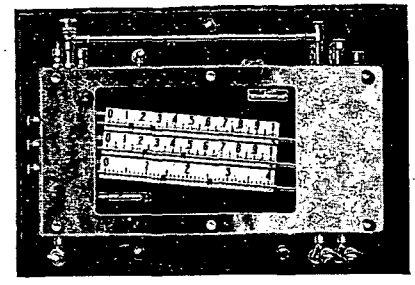
OPEN TYPE INCLINED: *For laboratories and technical institutions, 1, 1½, 2, 3, 5 inches range. Suspension plate relieves the gage from mounting strains, level adjusted with left suspension. Furnished with and without portable attachments. White metal scale.*



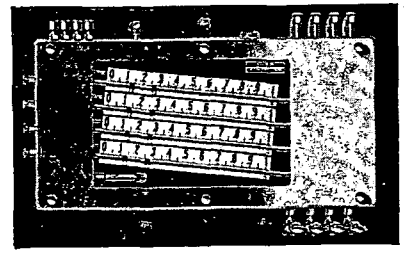
PORTABLE INCLINED: *This gage was designed for traveling engineers, light and compact, ½, ¾, 1, 1½, 2 inches scale range. Furnished with attachments in pressed aluminum carrying case for one or two gages. Half-inch gage set ideal for heating engineers.*



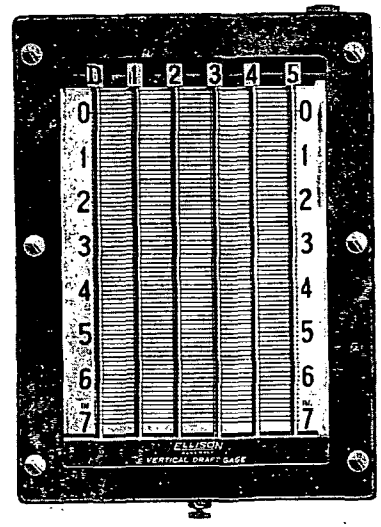
TWO-TUBE INCLINED: *By means of the differential system, this gage reads 1 to 1½ inch furnace draft and differential simultaneously; flue and furnace drafts when cock is closed. Without differential system, 1 to 7½ inches range.*



THREE-TUBE INCLINED: *This gage is furnished with or without differential systems, with scales 1 to 1½ inch range of like readings or a combination of readings from 1 to 7½ inches scale range.*



FOUR-TUBE INCLINED: *This gage reads suction or pressure, 1 to 1½ inches of like readings or a combination of readings from 1 to 7½ inches.*

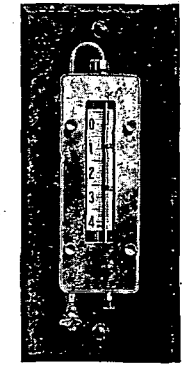


MULTI-TUBE VERTICAL: *This gage is for the duct and zone pressures of forced draft traveling grate stokers. It is made in 3, 4, 5, 6, 7, 8, 9, 10, 11, 12 tubes, in 7 and 10 inch scale range, with white enameled sliding scale, requiring no refilling for several years. By means of an equalizer all chambers are filled in one filling. Furnished with panel or for gage board, complete with back connection fittings. Printed paper scales are furnished for marking the load curves, Firing Guide, inserted over the metal scale by simply removing the cover.*

SINGLE-TUBE VERTICAL: *This gage is made in four sizes, 4, 7, 12, 20 inches scale range for suction, pressure or differential, for gage board and with and without panel.*

Like the stationary inclined gages, the scale is white enameled, readings visible across the boiler room. With the sliding scale feature, the gage requires no refilling for several years.

The efficient pressure range is carried between pointers, set by removing the cover.



DRYING SYSTEMS Inc.

ENGINEERS

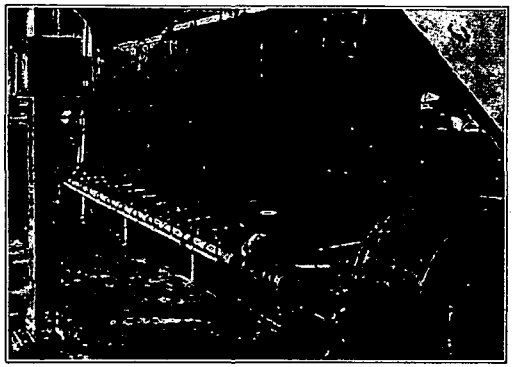
1800 Foster Avenue

CHICAGO-ILL.

Air Conditioning, Varnish Drying, High Temperature Baking, Heat Treating and Heating Equipment.

WHILE the designing, manufacture and installation of drying systems is an essential part of our business, we should first be considered as engineers—specialists in problems involving drying, high temperature baking, processing, ventilating and air conditioning.

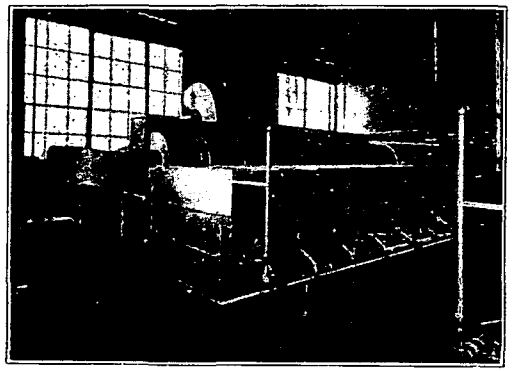
The accompanying photographs illustrate two types of Drying Systems, Inc., high temperature equipment which deliver air at temperatures ranging from 250 deg. to 700 deg. fahr. An air washer, or Automatic Filter, is usually installed in connection with these heaters. This equipment, built in unit sections, is exceptionally economical, as well as entirely safe. It is being successfully applied for drying and baking decorative finishes in many diversified industries and for the processing of a number of different materials.



The Lawrence Heater

We manufacture an Induced Draft Heater, in which the working air is mixed with the products of combustion. This equipment is particularly adaptable for drying articles which are finished with a preservative coating, and for the drying of such materials as abrasives, insulating products and foundry cores.

Practically every drying or heating installation presents new conditions and different engineering problems. Our staff of experienced engineers, specialists in Air Conditioning, is available to analyze your individual requirements —without obligation. We invite correspondence and requests for literature covering any particular problem.



The Allosteel Heater

The utilization of waste heat is a highly developed practice offering many opportunities for scientific waste heat equipment. Some unusual and very satisfactory installations of this equipment have been made in a number of different industries, practically eliminating hitherto material operating costs. Wherever hot, effluent gases are available, great economies can be effected by conserving this heat. In many cases such heat can be used advantageously for drying, baking and space heating, since the effluent gases are not mixed with the delivered air.

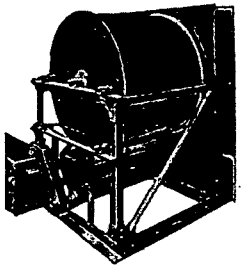


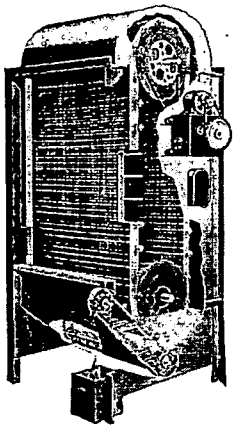
Typical Installation of Automatic Air Conditioning Equipment in Modern Bakery

AIR CONDITIONING

By arrangement with the American Blower Company, manufacturers of Sirocco Equipment, and through the acquisition of a staff of specialists in this work, we are prepared to offer Air Conditioning Service in all its branches. Special installations for paper mills, bakeries, candy factories, public and manufacturing buildings have been conspicuously successful. Bulletins and information covering this subject will be forwarded on request. A consultation with our air conditioning specialists places you under no obligation.

National ***Rotary*** *Air Filter*





Phoenix ***Constant-Effect*** *Air Filter*

The Phoenix *Constant-Effect* and the National *Rotary* Air Filters are advanced types of viscous film filters applicable for any service wherein clean air is required. These filters are automatic and comprise four important exclusive features, namely:

Unvarying Cleaning Efficiency
Constant Resistance
Self Cleaning
Minimum Operating Cost

Both Air Filters are built in sizes which are readily adaptable to any requirements —they are furnished in units, which range in capacity from 2,000 to 50,000 c.f.m. For larger air capacities, filters of multiple units can be furnished. Bulletins covering this subject thoroughly and illustrating sizes and installations, will be sent upon request.

ESTABLISHED 1841

E. B. Badger & Sons Co.

Manufacturers of Expansion Joints for High and Low Pressure

OFFICE AND WORKS
63-75 Pitts Street, BOSTON, MASS.

SALES OFFICE
101 Park Avenue, NEW YORK

Badger Self-Equalizing Expansion Joints

The Badger Self-Equalizing Expansion Joints are made from special seamless copper tubing, fitted with cast iron or steel rings to control the expansion and provide equal distribution over each corrugation.

The joint is made in Standard and Extra Heavy patterns, and unless otherwise specified will be furnished with standard flanges for pressure up to 125 pounds and extra heavy flanges for all pressures from 125 pounds to 200 pounds.

Monel metal sleeves can be furnished fitting inside of the corrugations, for use with super-heated steam and other high temperature fluids.

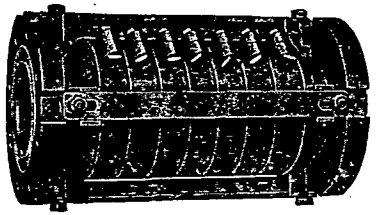


Fig. 1

This type of Joint is furnished in 4 in. and 5 in. sizes, with four and eight corrugations to take 1 in. and 2 in. of expansion. For smaller sizes, we furnish a 4-in. joint with companion flanges, bolts and gaskets, tapped for the size required.

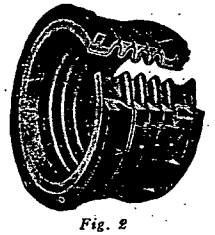


Fig. 2

This type of joint is made in sizes from 6 in. to 20 in. inclusive, with two, three, four or five corrugations, 2¼ in. deep, each corrugation taking ½ in. of expansion.

Specifications on Badger Expansion Joints

Fig. 1

Size Inches	FOUR-CORRUGATION			EIGHT-CORRUGATION			Add to List Prices for Extra Heavy Flanges
	Face to Face Inches	Finished Weight Pounds	Price Each	Face to Face Inches	Finished Weight Pounds	Price Each	
4	12⅞	65	$76.00	19⅞	95	$102.00	$4.60
5	12⅞	78	82.00	19⅞	110	110.00	5.35

For sizes up to 3½ in. inclusive, add $4.00 net to price of 4-in. joint for American Standard 125 pound companion flanges, bolts and gaskets; and $5.00 net for Extra Heavy American Standard flanges, bolts and gaskets, tapped to size required.

Fig. 2

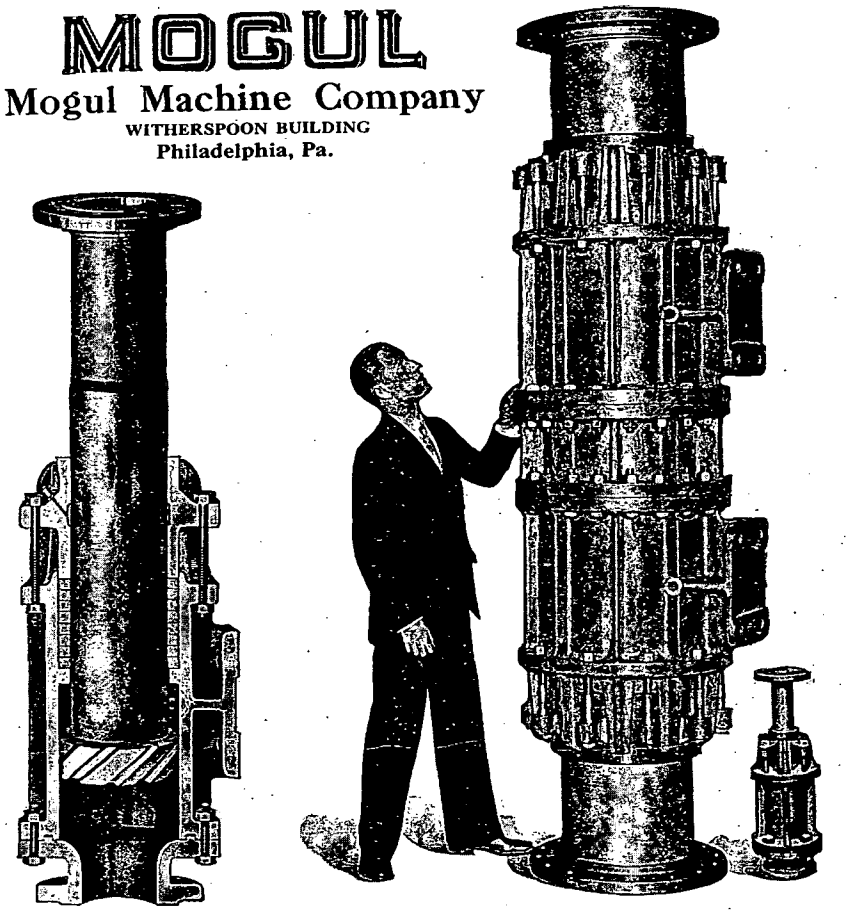
Size Inches	Two Corrugation			Three Corrugation			Four Corrugation			Five Corrugation			Add to List Prices for Ex. Hy. Flanges
	F/F Inches	Fin. wt. Pound	Price Each	F/F Inches	Fin. wt. Pounds	Price Each	F/F Inches	Fin. wt. Pounds	Price Each	F/F Inches	Fin. wt. Pounds	Price Each	
6	12½	146	$126.00	16	200	$155.00	19	236	$187.00	22½	285	$216.00	$ 7.43
8	12½	187	156.00	16	250	188.00	19	293	211.00	22½	345	243.00	13.25
10	12½	258	182.00	16	325	219.00	19	395	254.00	22½	465	291.00	17.05
12	13	338	222.00	16½	410	262.00	19½	493	300.00	23	570	340.00	21.63
14	13½	404	252.00	17	490	296.00	20	576	337.00	23½	660	381.00	24.55
16	13½	476	285.00	17	570	334.00	20	672	382.00	23½	765	431.00	34.15
18	14	546	320.00	17½	645	374.00	21	760	428.00	24	861	483.00	53.84
20	15	669	388.00	18½	765	450.00	21½	911	511.00	24¼	1010	573.00	56.48

Sizes larger than 20 in. can be furnished on special order.

MOGUL

Mogul Machine Company

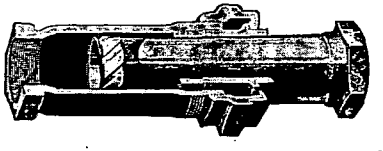
WITHERSPOON BUILDING
Philadelphia, Pa.



"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.**

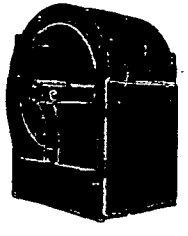
American Blower Company

General Offices: Detroit

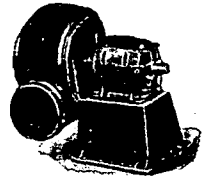
Branches and Sales Offices

City and Address	Telephone
Atlanta, Ga., Bona Allen Bldg.	Walnut 5643
Baltimore, Md., American Bldg.	Calvert 3743
Birmingham, Ala., American Trust Bldg.	Main 1278
Boston, Mass., 10 High St.	Liberty 8347
Buffalo, N. Y., White Bldg.	Seneca 2668
Charlotte, N. C., Piedmont Bldg.	1254
Chicago, Ill., 140 S. Dearborn St.	Central 1631-1632
Cincinnati, Ohio, Keith Bldg.	Main 1934
Cleveland, Ohio, Swetland Bldg.	Superior 1066-2198
Columbus, Ohio, First Nat'l Bank Bldg.,	Main 3443 (Bell)
Dallas, Texas, Mercantile Bank Bldg.	X-5518
Davenport, Iowa, Kahl Bldg.	Davenport 2458
Denver, Colo., 1228 California St.	Main 3155
Detroit, Mich., 2539 Woodward Ave.	Cadillac 8880-8881
El Paso, Texas, P. O. Box 240	Main 2739
Grand Rapids, Mich., Shepard Bldg.	Main 367 (Bell) 51122 (Citizens)
Indianapolis, Ind., Continental Bank Bldg.	Main 4545
Kansas City, Mo., Mutual Bldg.	Victor 5965
Louisville, Ky., 428 South Fifth St.,	Main 1881, City 1223

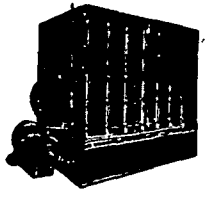
City and Address	Telephone
Los Angeles, Cal., Detwiler Bldg.	TUcker 9440 VAndike 4838
Milwaukee, Wis., Majestic Bldg.	Grant 1986
Minneapolis, Minn., 808 La Salle Ave.	Main 0034
New Orleans, La., 344 Camp St.	Main 5971
Newark, N. J., 79 Ogden St.	Branch Brook 3612
New York, N. Y., 50 Church St.	Cortlandt 1010
Omaha, Neb., Peters Trust Bldg.	ATlantic 6548
Philadelphia, Pa., 112 S. 16th St.	Rittenhouse 6393-94 (Bell)
Pittsburgh, Pa., Oliver Bldg.	Atlantic 1820
Portland, Ore., 1002 Pacific Bldg.	Broadway 7866
Rochester, N. Y., Cutler Bldg.	Main 4590
Salt Lake City, Utah, Dooly Bldg.,	Wasatch 1680-1681
San Francisco, Cal., Rialto Bldg.	Kearney 2325
Seattle, Wash., Leary Bldg.	Eliott 0713
Schenectady, N. Y., 147 Jay St.	Schenectady 7622-W
St. Louis, Mo., Boatmen's Bank Bldg.	Main 2395
Syracuse, N. Y., 1611 E. Genesee St.	Warren 8054-J
Tacoma, Wash., 1127 St. Paul Ave.	Main 3150
Tampa, Fla., 206 South Franklin	3453



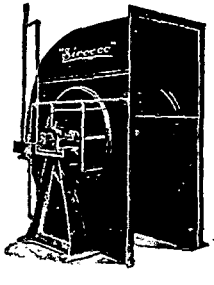
"Sirocco" Fans and Blowers for heating, ventilating, cooling, drying and mechanical draft.



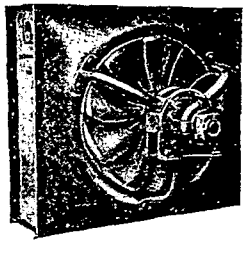
"Sirocco" Utility Blower—a compact, durable ventilator for installation with ducts.



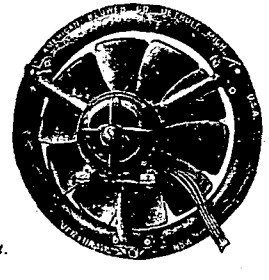
"Sirocco" Air Washer — for purifying and humidifying air for dehumidifying and cooling.



"ABC" Air Washing and Cooling Fan—an automatic, highly effective and durable unit that provides for purification, humidification 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.



"Ventura" Disc Fan for operation under free air delivery conditions — a complete ventilation system in itself.

Descriptive Catalogues sent upon request.

Buffalo Forge Company

Associated With

Carrier Air Conditioning Company of America

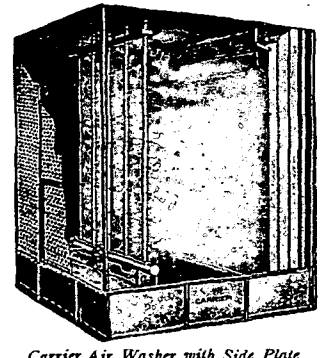
Buffalo, N. Y.

BRANCHES

New York, N. Y., 39-41 Cortlandt St.
Philadelphia, Pa., 1302 Land Title Bldg.
Boston, Mass., 10 Milk St.
Cleveland, O., 368 Rockefeller Bldg.
Pittsburgh, Pa., 927 Union Arcade
Detroit, Mich., 2051 W. Lafayette Blvd.
Chicago, Ill., 562 W. Wash. Blvd.
Atlanta, Ga., Candler Bldg.
Washington, D.C., 418 Washington Loan & Trust Bldg.
St. Louis, Mo., 515 Chemical Bldg.
Cincinnati, O., 604 Mercantile Library Bldg.
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CANADIAN BRANCH

Canadian Blower and Forge Co., Kitchener, Ontario



Carrier Air Washer with Side Plate Removed. Note Spray in Operation

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 Beezo Propeller Fans are very useful for removing steam, odors or foul air in shops, mills and factories. Belted or direct motor driven types.

Buffalo Stoker Fans have highest efficiency at normal load where it counts most, utmost proven reliability, and high speed for direct connection to turbine or motors. They completely protect motors.

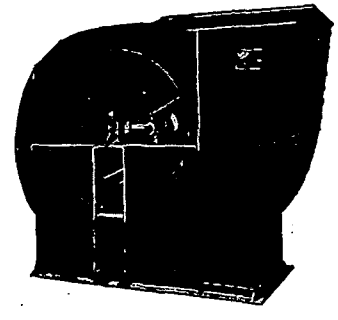
CARRIER AIR WASHERS

One-piece eliminators and scrubbers that are easily assembled in a few minutes and give greatest cleaning effect known. Spray nozzles prevented from clogging by tank-width screen. Original efficiency is maintained indefinitely by a few minutes flushing out each week.

Power Blowers and Exhausters have cast iron housings and are for belt or direct motor drive.

Mill Exhausters. Standard and slow speed, high efficiency, and single or double exhausters are furnished for handling refuse or dust. For belted or direct drive.

Buffalo Duplex Conoidal Fans, shown below, maintain even pressure 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.



Send for Catalogue

Buffalo Products

Conoidal Multiblade Fans
Carrier Air Washers
Pipe Coil Heaters
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Disc Fans
Humidifiers
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Gas Scrubbers
Stoker Fans
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Planing Mill Exhaust Fans
Dust Collectors
Pressure Blowers
Drying Apparatus
Spray Nozzles
Forge Shop Equipment

Clarage Fan Company

Kalamazoo, Michigan

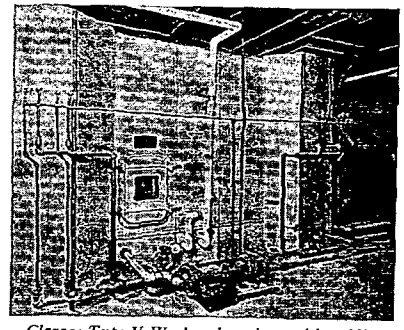
BOSTON, MASS.
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HUNTINGTON, W. VA.
BUFFALO, N. Y.
NEW ORLEANS, LA.

Consult Telephone Directory for Street Address of any of above Branch Offices

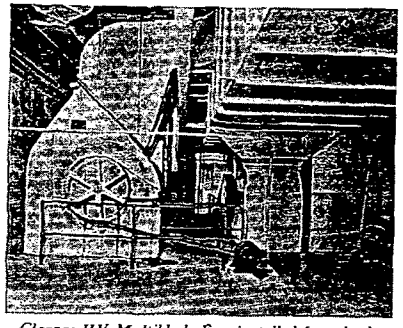
Products—Heating and Ventilating Fans and Allied Apparatus, Multiblade Fans, Air Washers, Exhaust Fans, Pressure Blowers, Mechanical Draft Equipment, Heaters, Vertical Steam Engines.

New Type HV Fan—Tested in accordance with the Standard Test Code, prepared by National Association of Fan Manufacturers and AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS, Clarage New HV Multiblade Fan, shows 77 per cent maximum efficiency. Average multiblade fans show approximately 63 per cent maximum efficiency. This higher efficiency allows saving of 15 to 20 per cent in power requirement to drive. Lower power requirement often allows use of smaller motor or engine, saving 10 to 15 per cent. Often HV Fan one size smaller will meet specifications, saving 15 to 20 per cent in first cost of fan equipment.

Built in complete range of sizes for heating and ventilating schools, offices, theatres, churches, factories, etc. Capacities from 500 to 236,000 C. F. M. Constructed to a quality standard for continuous duty at low upkeep. Furnished with babbitted, self-aligning, ring-oiling bearings, having special felt washer feature which keeps oil in and dirt out. Can be motor, engine or turbine driven by belt or direct connected.



Clarage Type V Washer cleansing and humidifying air in large hotel.



Clarage HV Multiblade Fan installed for schoolhouse ventilation.

Improved Type V Washer—Spray nozzles so perfected that dense mist screen is obtained at lower pump pressures, effecting marked saving in horse power for operating pump. Spray nozzles cannot clog. New construction of eliminator plates greatly simplifies erection. Suitable for all types of washed air installations. Performance fully guaranteed. Range of sizes to cover every requirement.

Cooperative Service—Our engineers have compiled elaborate data on every Clarage product. This data will prove valuable in selecting the most practical and efficient equipment. We will gladly cooperate in every way possible. Write for Clarage literature or ask to have a Clarage Engineer call.

CLARAGE TYPE HV FAN CAPACITIES

Size of Fan	1200′ OUTLET VELOCITY					1800′ OUTLET VELOCITY								
	Volume of Air C. F. M.	½″ S. P.		1″ S. P.		Volume of Air C. F. M.	½″ S. P.		1″ S. P.		1½″ S. P.		2″ S. P.	
		R. P. M.	B. H. P.	R. P. M.	B. H. P.		R. P. M.	B. H. P.	R. P. M.	B. H. P.	R. P. M.	B. H. P.	R. P. M.	B. H. P.
1½	2,322	402	.31	549	.55	3,482	480	.68	579	.97	683	1.30	775	1.65
1¾	3,156	345	.43	471	.74	4,734	412	.93	497	1.32	585	1.77	665	2.24
2	4,128	301	.56	411	.97	6,192	360	1.21	433	1.73	512	2.31	580	2.93
2¼	5,220	267	.70	364	1.22	7,830	319	1.53	384	2.18	453	2.92	514	3.70
2½	6,444	242	.86	330	1.51	9,666	289	1.88	348	2.69	410	3.61	465	4.58
3	9,288	201	1.24	275	2.17	13,932	241	2.71	290	3.88	341	5.20	388	6.59
3½	12,660	170	1.80	236	2.90	18,990	199	3.70	244	5.07	286	6.77	332	8.70
4	16,524	149	2.35	206	3.79	24,786	175	4.83	214	6.62	250	8.82	290	11.4
4½	20,880	132	2.96	183	4.79	31,320	155	6.09	189	8.35	222	11.1	258	14.4
5	25,800	119	3.65	165	5.92	38,700	139	7.54	171	10.3	200	13.8	232	17.8

Range of Sizes include No. ½ to No. 9 inclusive.

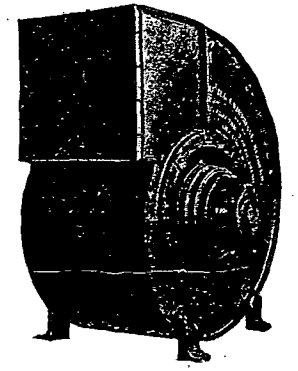
Ilg Electric Ventilating Company

General Offices and Works:

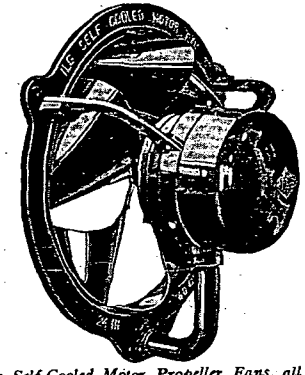
2880 N. Crawford Avenue ∴ CHICAGO, ILL.

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325 Commercial Trust Bldg.
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Hearst Tower Bldg.
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CLEVELAND
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PITTSBURGH
1024 Bessemer Bldg.
MINNEAPOLIS
442 Builders Exchange Bldg.
CINCINNATI
405 Union Central Bldg.
DETROIT
204 Owen Bldg.
BOSTON
136 Federal St.
INDIANAPOLIS
905 National City Bank Bldg.
ROCHESTER
941 Granite Bldg.

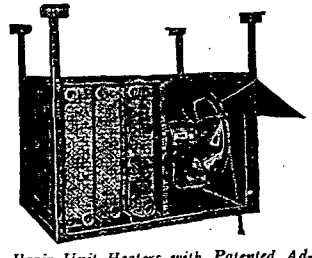
HIGH EFFICIENCY TRADE ILG MARK VENTILATING MACHINERY



Ilg Universal Blowers—Direct Connected and Belted—no bearings in inlet. Ball-bearing, grease lubricated motors. Sizes 10 in. to 100 in.



Ilg Self-Cooled Motor Propeller Fans, all sizes for any current or voltage, kept in stock 12 in. to 72 in.



Ilgair Unit Heaters with Patented Adjustable Deflector. For floor type or ceiling type. Lowest power consumption—easily connected to outside air.

CATALOGS

Complete Catalog, 200 Pages
Condensed Catalog, 48 Pages

BULLETINS

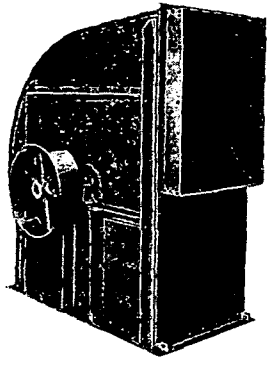
Unit Heaters
Garage Heating
Fog Reduction and Steam Removal
Restaurant Ventilation
Residence Ventilation
Store and Office Ventilation
Power Roof Ventilators
Farm Ventilation
Fans and Blowers for Railroads
Industrial Ventilation
Ilg Fans Everywhere

The New York Blower Company

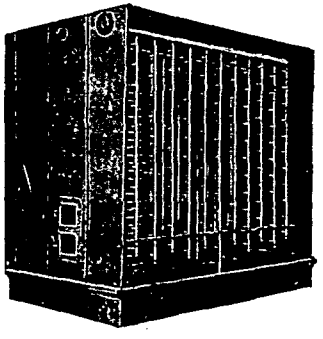
2254 S. Halsted Street, CHICAGO ILL.

SALES OFFICES IN PRINCIPAL CITIES

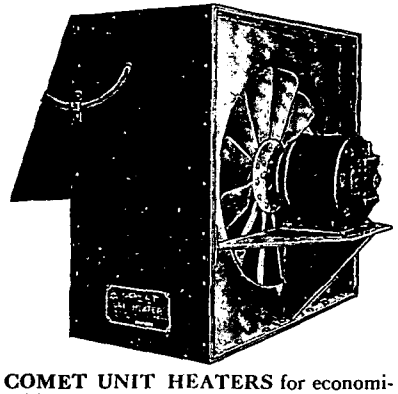
Fans—Blowers—Unit Heaters—Air Washers—Fan Furnaces—Ventilators



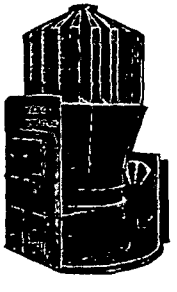
TYPE ME Fans for heating and ventilating public buildings, schools, theatres, factories, mines, etc. Fans for mechanical draft, conveying systems, foundries, gas plants, stokers. Pulley driven or motor driven disc and propeller fans of wide range. Write for bulletin 100 giving complete data.



PEERLESS AIR WASHERS for public and industrial buildings. Cooling systems for theatres, auditoriums, churches, department stores, etc. Humidifiers and de-humidifiers for special processes and drying, as paper, textiles, tobacco, glue, leather and wood.



COMET UNIT HEATERS for economical heating and ventilating where steam is used. Write for bulletin No. 85 describing these compact units and how efficiently they heat garages, factories, foundries, offices, etc.



THERMAIR FAN FURNACE equipped with Heavy Duty Disc fan occupies a floor space of six feet square. Delivers over 600,000 B.t.u. per hour and will heat any building with 10,000 square feet floor area. Easy to install as no duct work is needed. Bulletin No. 90 gives complete data.

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PUTS AIR TO WORK

PLANTS LOCATED IN

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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. We hope you will avail yourself of their services.

CATALOGS

Heating and Ventilating Equipment

No. 227 Heating and Ventilating Layouts.
271 Multivane Fans.
283 Autoforce Ventilators.
290 Silentvane Fans.
297 Air Washers.
306 Hot Blast Heaters
322 Coal Burning Blowers.
323 Unit Heaters, Industrial.
328 Propeller Fans.
329 Unit Ventilators, Schoolhouses.
332 Ventilating Sets.
337 Monogram Fans.
1270 Motors.

Power Plant Equipment

No. 239 Steam Engines.
255 Generating Sets.
271 Multivane Fans
275 Gear Transmissions.
301 Cindervane Fans.
311 Steam Turbines.
330 Turbovane Fans.
331 Air Economizers.
334 Lead Coated Steel Tube Economizers.
1270 Motors.
Turbo-Undergrate Blower Specifications.

Collecting and Conveying Equipment

No. 291 Pneumatic Collecting and Conveying Systems.
302 Steel Plate Planing Mill Exhausters.
303 Reversible Planing Mill Fans.
291 Dust Collectors.
337 Monogram Exhausters.
1270 Motors.

Drying Equipment

No. 299 Drying Systems.
314 Moist Air Dry Kilns.
316 Industrial Dryers.
1270 Motors.

Blower Equipment

No. 257 Steel Pressure Blowers.
1266 Big Midget Blowers.

Vacuum Cleaning Equipment

No. 320 Stationary Vacuum Cleaners.
324 Heavy Duty Vacuum Cleaners.
Household Vacuum Cleaners.

L. J. Wing Mfg. Co.

Branch Offices in Principal Cities

663 Hudson St., 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 and Exhausters

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.

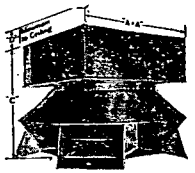
The installation of **Wing Featherweight Unit Heaters** is extremely simple, due to their light weight and small dimensions. For instance, a unit equal in heating effect to 12,000 sq. ft. of direct radiation, weighs only 332 pounds. A few advantages attending the installation of **Wing Featherweight 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.

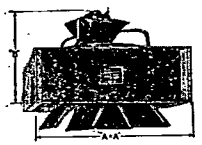
Since the air recirculated by the heaters is taken from the upper spaces and delivered to the lower levels, it is evident that an active circulation of air from the ceiling to the floor is continuously maintained and that, therefore, excessive heat is not allowed to accumulate in the upper spaces, as is the case with any system of heating that allows the heat to rise to the ceiling immediately, as it does in the case of direct radiation.

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.



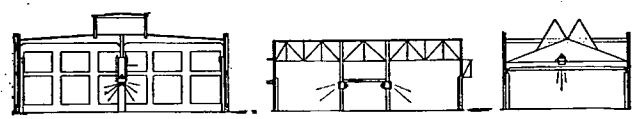
Low Ceiling Type

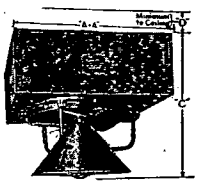


High Ceiling Type

METHODS OF INSTALLATION

The cuts show three different methods of installation, the units in each case being located well above the head line, out of the way. The third illustration shows the high ceiling type heater installed thirty feet from the floor above a traveling crane. 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.

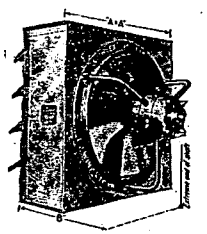




Medium Ceiling Type

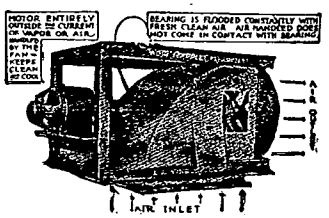
Condensed Table of Engineering Data

Unit Size	"AxA" in.	B in.	C in.	D in.	Air c.f.m.	Motor hp.	Temperature Room	Temperature Leaving	B.t.u. per Hr. Available	Approx. Shipping Weight Lbs.
13-4-12	19¾	25	25	6	1150	⅛	60	110	69,500	185
17-3-12	22¼	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	39⅞	39⅞	8	9600	2	60	122	579,000	504
36-5-85	46⅛	39⅞	39⅞	8	9000	2	60	133	623,000	528



Horizontal Type

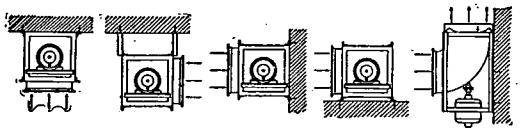
Space does not permit complete table for other room temperatures but this data will be gladly furnished on application.



Wing-Scruplex Exhauster

WING-SCRUPLEX EXHAUSTERS

Wing Scruplex Exhausters consist of the highly efficient "screw propeller" fan and cased 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 accompanying diagrams show the methods of installation.



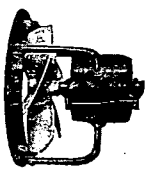
Bolted directly to Ceiling | *Hung from Ceiling* | *Bolted directly to Side Wall* | *Bolted to Floor or Foundation* | *Vertical Bolted to Side Wall*

"WING-SCRUPLEX" EXHAUSTERS

Proper Selection of Exhausters—Where particularly quiet operation is desired, as in offices, residences, hospital wards, churches theatres, etc., use lowest speeds in all sizes. 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, hotel and restaurant kitchens, engine-rooms, workshops, etc., use any speeds.

The accompanying table gives performances at static pressures up to ½ in. Complete table up to 1 in. static on request.

Size	Inlet Sq. In.	Outlet Round. In.	Speed R. p. m.	Free Air Cu. f. m.	Free Air Hp.	.15 in. Cu. f. m.	.15 in. Hp.	.25 in. Cu. f. m.	.25 in. Hp.	.40 in. Cu. f. m.	.40 in. Hp.	.50 in. Cu. f. m.	.50 in. 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	17⅜	850	2130	0.090	1250	0.110	.....	.....	.....	.....	.....	.....
3-A	16¾	17⅜	1150	2700	0.180	2150	0.195	1550	0.221	.....	.....	.....	.....
3-C	16¾	17⅜	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	0.125	1610	0.150	.....	.....	.....	.....
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	.....	.....	.....	.....
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 Fan

WING-SCRUPLEX FANS

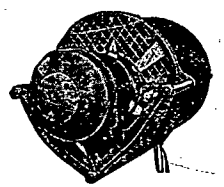
Wing Scruplex Fans are built in the following sizes: 10 in., 13 in., 17 in., 22 in., 25 in., 30 in., 36 in., 42 in., 54 in., and 60 in. Capacities from 950 C. F. M. to 33,000 C. F. M. Up to 25 in. diameter, propellers are made of cast aluminum alloy while the larger sizes are of pressed steel.

WING TYPE E M MOTOR DRIVEN 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. Where Wing units cannot be set directly into the brick base of the boiler, they are equipped with feet or base and mounted to the floor with the discharge connected to the ashpit by a short sheet metal duct.

Ask for Bulletin 36

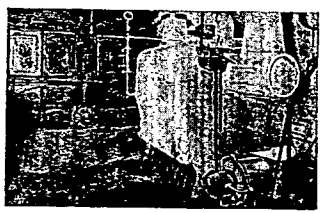


Type E M Blower

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 of prime importance is variable speed control; this permits of regulation without the use of dampers and saves power.

Wing Blowers are cutting down fuel bills in hundreds of schools, apartment houses, lofts, hotels, churches and institutions throughout the country. Booklet 36 describes Wing motor-driven units.

Information on Wing turbine-driven units in Bulletin 77.

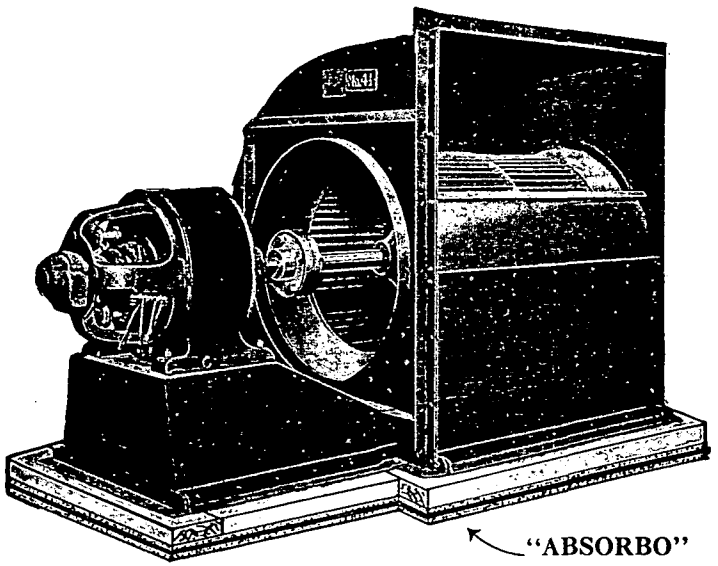


Typical installation in a New York apartment house where the use of Buckwheat coal in place of domestic sizes is saving the owner a large part of his previous fuel bill. In the right foreground is shown an E M Blower connecting directly into the rear end of a cast-iron hot water boiler; the E M Blower in the background serves the two steam heating boilers. Note how compact this installation is—a characteristic of Wing E M Blower layouts.

Cork Foundation Company

315 Fifth Avenue, New York

NOISE is a great detriment to work. It hinders and annoys. Elimination of vibration and the noise made by the whir of fans and motors is possible by the use of "ABSORBO" beneath the base of the apparatus—as shown in the illustration.



"ABSORBO" is made of prepared strips of natural cork 1½ in. thick, set in rigid steel frames, with lateral braces wherever required. In the process of preparation the cork is impregnated with creosote to render it impervious to oil and water and to preserve its natural oil and moisture.

In most installations where "ABSORBO" is used, it is placed under the timber frame of the machine. In foundations for engines, compressors, turbines and large pumping units, it has been advantageous to place it under the concrete base, with a layer on the sides of the concrete foundation to eliminate the horizontal vibrations.

Specifications for its installation and test data on its effectiveness in absorbing vibrations and eliminating noise will be gladly furnished.

The Korfund Company

231 EAST 42nd STREET **New York, N. Y.**

BOSTON
PHILADELPHIA
PITTSBURGH
CLEVELAND
COLUMBUS

ABSORBS VIBRATIONS

CINCINNATI
ST. LOUIS
CHICAGO
DETROIT
OTTAWA, CAN.

KORFUND
FOR THE ISOLATION OF NOISE AND VIBRATION

The essential qualities of a good isolating material are: permanent and sufficient elasticity; structural strength to sustain load; durability and indestructibility; water, oil, acid and insect-proof.

These requirements make artificially pre-compressed materials such as special felts, layers of woven materials, compressed cork, etc., unsuitable as they must be pre-compressed to such a density that their elasticity is made illusory. The isolating effect or the materials themselves will be destroyed through the action of oil and water.

Pure natural cork, and by that is meant the cork as it is taken from the bark of the Cork Oak, possesses the necessary qualities of the ideal isolating material to a greater degree than any other material.

Experience extending over many years has proved that natural cork is indestructible, impervious to water and acids if properly treated, and possesses such high resilience that it is considered the best isolator for all kinds of machinery.

KORFUND pads are made up in the following way:

The strips or blocks of natural cork, specially selected for this purpose, are carefully cut to size and bound together with an iron frame which is not quite as thick vertically as the cork. No artificial binder is used for the reason that such binder hardens and destroys the resilient, shock-absorbing and sound-deadening effect of the cork, or is liable to be dissolved through the action of oil and alkalis.

The frames of all KORFUND plates are made of heavy steel, reinforced by internal longitudinal and lateral struts. This construction is substantial and strong and gives adequate support to the cork strips.

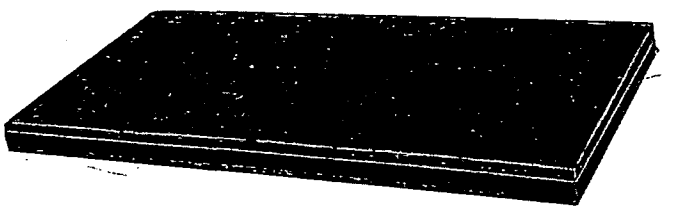
The cork used for KORFUND pads is treated by a special process to preserve the normal degree of moisture which is so vital to it. KORFUND pads thus treated will not decompose or decay.

With larger pumps, compressors and other machinery, especially if they are of the reciprocating type, KORFUND must be arranged under the foundation block proper. Then the weight of the foundation block will help to steady the machine and the foundation bolts will not have to pass through the cork pads. Proper side isolation has to be provided where necessary. With smaller pumps and compressors of the centrifugal type, also with fans, the machinery may be placed direct on KORFUND. In such a case timber or a steel plate has to be placed on KORFUND before mounting the machinery in order to equally distribute the weight of the machine all over the surface of the cork.

KORFUND pads are made up in any size and thickness required. We carry a large stock of many different sizes for immediate delivery. No fitting, cutting and consequent waste of material will result on the job. They can be installed by unskilled help.

Many thousands of installations of KORFUND for all kinds of machinery are in use all over the world. They are silent witnesses of its ability to absorb noise and vibration.

We are consulting engineers specializing in the isolation of noise and vibration. Our advice is at the disposal of our customers. Write for catalogue "H".

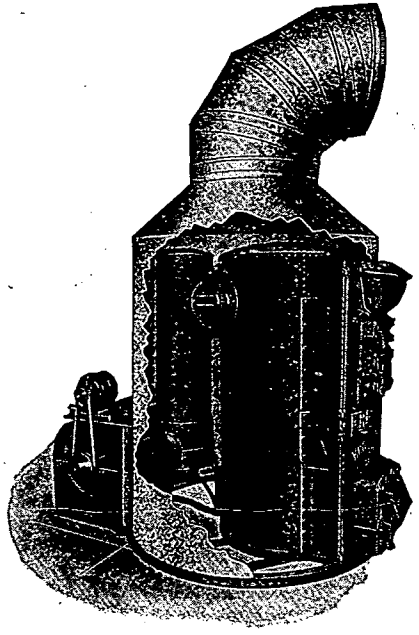


Langenberg Manufacturing Co.

4549 No. Euclid Ave. :: ST. LOUIS, MO.

FRONT RANK
TRADE NAME REGISTERED

Dealers in all parts of the United States



A QUALITY COMBINATION

A FRONT RANK FURNACE; Twin Sirocco Fan with S K F Bearings; New Design Casing. All assembled into the

FRONT RANK
UNIT HEATER

FUELS—

Any coal, coke or oil.

Operates by fan or gravity. No by-pass dampers necessary.

Churches, schools, stores, auditoriums, small factories, residences and garages where these plants have been installed and now operate successfully are our best references.

We design and install our own systems anywhere in the United States or Canada.

DATA ON FRONT RANK UNIT HEATER

No. of Fan Units	Diam. Casing Inches	Diam. Drum Inches	Diam. Fire Pot Inches	Depth Fire Pot Inches	Area of Grate Sq. In.	Diam. of Rad. Inches	Height of Rad. Inches	Height of Drum Inches	Height of Unit Overall With One-Way Outlet	Diam. Smoke Pipe Inches
U-453	45	22	20	15	283	10	35	58	8'	9
U-513	51	26	23	15	380	11	35	59	8'	9
U-573	57	29	26	15	490	13	38	62	8'-9"	10
U-661	66	32	29	19	616	18	41	69	9'-6"	10
U-661-H	66	32	29	19	616	18	58	97	12'	10

Area of Outlet In Sq. In.	Size at Feed Door Openings Inches	Cu. Ft. Air per Minute Fan	Cu. Ft. Air per Minute Gravity Approximately	R. P. M. of Fan	Diam. of Fan Inches	H. P. Required	Approximate Shipping Weight Including Motor Lb.	B.t.u. Guaranteed at 9 lb. per sq. ft. (See Note)
452	12x13½	3500	1400	365	18	½	1350	180,576
616	12x13½	3900	1570	390	18	½	1550	252,396
707	12x13½	4400	1750	314	21	¾	1850	314,640
1018	12x13½	5900	2400	238	24	¾	2150	383,040
1018	12x13½	7000	2600	275	24	1	2250	406,980

NOTE:—When burning Illinois Coal producing about 12,000 B.t.u. as ordinarily burned. Other fuel will give different rating. Unless otherwise specified, furnace will be rated on 9 lb. of coal per sq. ft. of grate when estimated.

Neemes Foundry, Inc.

Established 1874 **TROY, N. Y.**

Branches in 20 Cities

PRODUCTS:

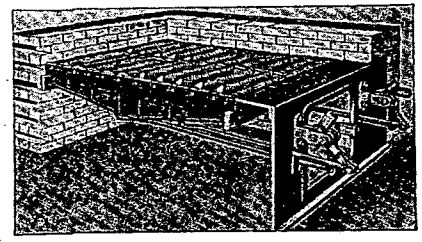
NEEMES IMPROVED SHAKING AND DUMPING GRATES; SUPERIOR DUMPING GRATES; HAND-OPERATED STOKERS.

Also all types of Stationary Grates.

NEEMES GRATES:

Suitable for Burning All Kinds of Fuel: Neemes Improved Shaking and Dumping Grates and Straight Dumping Grates are built to fit *rectangular* and *circular* furnaces of internally and externally fired boilers and can be installed without alteration of brickwork.

Grates are suitable for all sizes and grades of anthracite and bituminous coal, slack, lignite, tan bark and admixtures of coal and sawdust.



Neemes Improved Shaking and Dumping Grate

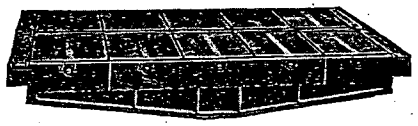
Dominant Features of Neemes Grates: Patented lock box holds shakers in place and prevents their being forced up into the fire and burned, yet does not interfere with ready removal of shakers.

Fire shaken and dumped with very little effort. Dead air spaces reduced to a minimum. No special setting required, as grates rest on usual bearing bars or dead plate lip. All castings spaced to allow ample side and end play, preventing warping and buckling.

Clinkers cut and crushed in center of concave surface of teeth and not on the point—no broken teeth result. Clinkers cut and ashes shaken out without breaking up fuel bed or loss of unburned fuel; periodical slicing of fires is not necessary.

Grates do not clog with ashes, as air slots are widened out below the surface, permitting any ash small enough to pass top space to fall into pit.

No screws or bolts are used in grate proper, thus removal and replacement of parts is greatly facilitated.



Neemes Superior Dumping Grate

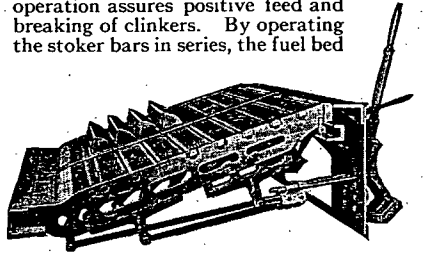
Adapted for Use with Forced Draft: Both the Neemes Improved Shaking and Dumping Grate and the Neemes Superior Dumping Grate are exceptionally well adapted for use with forced draft.

SERVICE RECORD OF NEEMES GRATES:

Neemes grates have been performing satisfactory service for the past 25 years and have been installed in boilers representing over 250,000 hp.

NEEMES HAND-OPERATED STOKER:

The Neemes Stoker operates at 15-degree pitch which obviates the necessity of a deep ashpit. The coal is fired onto the dead plate and coking bars at the front of the stoker only, and the large angle to which the stoker bars are raised during operation assures positive feed and breaking of clinkers. By operating the stoker bars in series, the fuel bed is kept at a uniform depth, and at the same time proper progress of the fuel is assured without mere churning. The dump plate is shaped to prevent avalanching of the fuel during dumping and to assure being completely covered with fuel after dumping. Side bars are anchored in place at the forward end only and rest in recesses at the rear end, so as to provide for free expansion.



Neemes Hand-operated Stoker

Bulletins and additional data on Neemes Grates and Stokers 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.

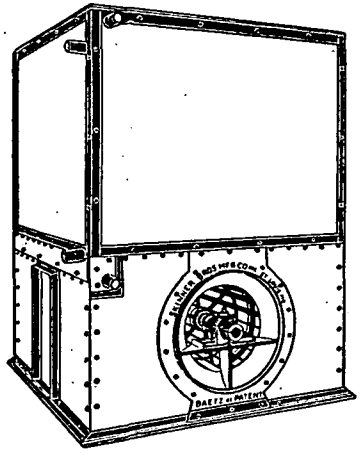
BALTIMORE	2 E. Lexington Street	INDIANAPOLIS	621 Illinois Bldg.
BOSTON	723 Little Bldg.	KANSAS CITY	412 Mutual Bldg.
BUFFALO	702 Morgan Bldg.	PHILADELPHIA	1011 Pennsylvania Bldg.
CHICAGO	1703 Fisher Bldg.	PITTSBURGH	715 Magee Bldg.
CLEVELAND	612 Marshall Bldg.	SEATTLE	929 Dexter Horton Bldg.
DETROIT	308 Scherer Bldg.	SPOKANE	409 First Avenue
WASHINGTON	714 Evans Bldg.		

Sales Offices in Principal Cities

Factories at ST. LOUIS, MO. and ELIZABETH, N. J.

Sole and exclusive manufacturers of Skinner Bros. Steam Coil 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



The New Improved Skinner Bros. Two-Fan Four-Inlet 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 automobile factories, furniture factories, garages and repair shops, railway shops, foundries, shoe factories, stone and marble works, flour mills, textile mills, warehouses.

Skinner Bros. Steam Coil Heaters are built in ten standard sizes and three models delivering from 75,000 to 4,630,000 B.t.u. per hour, and ranging in floor space occupied from 2 x 2 ft. to 7 x 7 ft. However, they are constructed in sizes and dimensions to fit the requirements they are called upon to fill in capacity and space occupied. For use where floor space is at great premium we supply an inverted type for overhead suspension.

Outlet hoods are designed to accomodate the conditions found in the buildings, one, two, three way, round or rectangular, being supplied.

Skinner Bros. Steam Coil Heaters function equally well with either live or exhaust steam, and high or low pressure may be used. The coils of every heater are tested with 150 lbs. of hydraulic pressure before leaving the factory. Whatever power is available may be used to propel the fans.

The performance of the heaters is guaranteed when they are installed as directed by our engineers.

In figuring the approximate capacities of the heaters engineers may be guided by the following for general purposes:

For each square foot of floor space occupied by the heater the power consumption for driving the fan is 1/12 H. P., and the air handled will be 400 to 450 C. F. M. with an output of 30,000 B.t.u., when steam pressure on the coils is five pounds and ingoing air at 60 deg.

DIMENSIONS AND CAPACITIES
Skinner Bros. Two-Fan Four-Inlet Steam Coil Heaters

Heater Designation	Height*	Floor Space Covered	H. P. Motor	R. P. M.	C. F. M.	B.t.u per Hour, Air Entering at 0° F.	
						5 lbs. Steam	100 lbs. Steam
20†	5′ 3½″	2′ 4″x2′ 4″	½	490	1,850	125,000	206,000
			1	635	2,450	159,000	265,000
20B†	6′ 2½″	2′ 4″x2′ 4″	½	490	1,850	142,000	236,500
			1	635	2,450	185,500	309,000
30	5′ 7½″	3′ 4″x3′ 4″	1	490	4,500	352,400	589,000
			2	620	5,800	460,000	770,000
30B	6′ 6½″	3′ 4″x3′ 4″	1	490	4,500	429,000	716,000
			2	620	5,800	544,000	910,000
40	6′ 11½″	4′ 4″x4′ 4″	1½	544	5,200	612,500	935,000
			2	600	6,000	668,000	1,020,000
40B	7′ 0½″	4′ 4″x4′ 4″	2	600	6,000	736,000	1,125,000
			2½	730	7,000	803,000	1,230,000
50	7′ 2″	5′ 5″x5′ 5″	2	525	8,300	995,940	1,538,000
			3	600	10,000	1,166,300	1,825,000
60	7′ 6″	6′ 6″x6′ 6″	3	400	12,000	1,453,000	2,222,800
			5	480	14,400	1,727,000	2,560,400
65	8′ 2″	7′ 0″x7′ 0″	4	420	14,000	1,695,000	2,610,000
			6	480	17,000	2,015,000	2,987,000
70	8′ 2″	7′ 6″x7′ 6″	7½	460	26,000	2,780,000	4,400,000
			10	500	28,500	2,960,000	4,630,000

*Not including outlet which is made to fit requirements.
†Made in 1 fan, 2 inlet style only.

SKINNER BROS. DIRECT FIRED HEATERS

Designed for use in buildings in which steam is not available. A heater that burns bituminous or anthracite coal, coke, wood, gas or oil. It is the pioneer of its type and not only has proved performance in factories, mills, shops, garages and industrial buildings of all kinds, but has been widely recommended by contractors for preventing the freezing of concrete, plaster and other materials during winter construction.

Skinner Bros. Direct Fired Heaters are built in three sizes, delivering from 50,000 to 150,000 B.t.u.

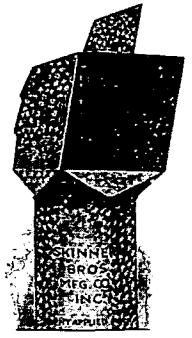
SKINNER BROS. REVOLVING SIPHON VENTILATORS

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 angles 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

Modine Manufacturing Co.

Manufacturers of TherModine System of Heat Distribution

Racine, Wis.

Branches in All Principal Cities

Products

THERMODINE COPPER TUBULAR RADIATING UNITS for Steam, Vapor and Hot Water Heat Distribution.

THERMODINE HEAT CABINETS.

MODINE UNIT HEATERS for Industrial Heating.

What TherModine Is

TherModine is the development of tubular copper automobile radiators to the distribution of heat for steam, vapor and hot water heating systems for buildings. The manufacturers are among the largest firms in the automobile radiator business, guaranteeing entire responsibility both for product, statements and deliveries.

TherModine Heating Sections

TherModine heating sections are built of pure 30 gauge copper tubes, crossed and reinforced by fins of the same metal, six to the inch, forming many small air passages. Tubes are expanded into brass heater plates secured to cast bronze headers.

Material and workmanship are guaranteed to be of the very best. Sections will withstand 50 lb. steam working pressure and 100 lb. water pressure. Copper and brass will last indefinitely, except where sulphurous and kindred acids occur which is very rare.

TherModine heating sections are guaranteed against failure for 5 years, except when they are used where large quantities exist of acids or alkalines which have strong affinities for copper.

Standard heating sections have tube lengths from 12 to 36 in. in even inches. Tube lengths divisible by 6 will be carried in stock. Sections are made in three widths: 12 T, 16 T, 20 T, which are 5¼, 7 and 8¾ in. wide, respectively.

Advantages of TherModine Over Cast Iron Radiators

Weight—TherModine weighs but 5 per cent of equal capacity cast iron radiators.

Influence on Design—Architects recognize the almost revolutionary changes in design made possible by TherModine and the elimination of the bulky cast iron radiators. As heated air leaves the TherModine upper grille horizontally there is none of the smudging of walls as over cast iron radiators.

Small room design where door clearances are so great a factor and furniture layout has been influenced by the presence of cast iron radiators, gain as much as 20 per cent in available floor area when TherModine is built into walls or partitions.

In the Wall Application—TherModine may be placed in a 4-in. partition wall. Architects are reporting many ingenious applications of TherModine behind built-in book cases, china cabinets, etc.

Heat Control

Every TherModine Stack or Cabinet has a tight fitting damper to control the heat. Dampers can be controlled by hand or by standard automatic temperature control systems. Hand valves are not needed.

Roughing-in Dimensions

Allow ¼ in. over-all dimensions for recesses. Sections are 4 in. longer over-all than tube length. Center to center of tappings is length of tubes plus 2¼ in.

HEATING CAPACITIES
B.t.u. per inch of length of tubes

Cabinets				Wall Stacks			
Over-all Height (H)	12 T	16 T	20 T	Over-all Height (H)	12 T	16 T	20 T
14″	180	240	295	20″	210	275	240
20″	220	295	365	30″	255	340	425
26″	260	345	430	40″	300	390	490
32″	290	385	480	50″	330	445	555
38″	315	420	525	60″	365	490	605
44″	340	455	565	70″	400	530	660
				80″	430	575	720

Above ratings based on steam at 212 ° F.
B.t.u. transfer based on 160° water equals one-half above.

The Herman Nelson Corporation

Moline, Illinois

BRANCH SALES AND SERVICE STATIONS

BELFAST, ME.	PHILADELPHIA	CLEVELAND	DES MOINES	EMPORIA	SPOKANE
BOSTON	SCRANTON	COLUMBUS	MILWAUKEE	OMAHA	PORTLAND
NEW HAVEN	PITTSBURGH	TOLEDO	MINNEAPOLIS	KANSAS CITY	SEATTLE
NEW YORK CITY	GRAND RAPIDS	INDIANAPOLIS	ST. LOUIS	DENVER	VANCOUVER
SYRACUSE	DETROIT	CHICAGO	SAN FRANCISCO	SALT LAKE CITY	TORONTO

Product: UNIVENT System of Ventilation.

Univent: The UNIVENT, which is electrically operated draws fresh air through the wall or window, cleans it, warms it to a comfortable temperature and diffuses this fresh air to every nook and corner of the room.

There are four UNIVENT models: "S," "S-D," "R" and "O."

Each of these models are made in various sizes and capacities to meet most problems in ventilation.

Cabinet: All models are 38 in. high. Model "S" and "S-D" 12½ in. deep, model "R" and "O" are 18½ in. deep. The width of the various models vary according to their capacity.

The UNIVENT cabinet is built of high grade furniture steel, properly re-inforced to insure utmost rigidity and durability.

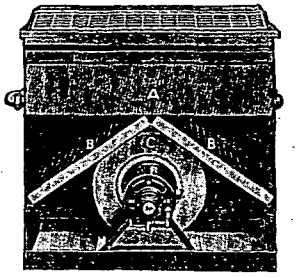
The light front panel is easily removed making all parts accessible for cleaning and inspection. The cabinet is regularly finished with olive green lacquer.

Radiator: The radiator is made of pure copper plates securely and tightly pressed to core of special silumin metal. Silumin metal is non-corrosive. This is a leak-proof, high capacity, last-forever radiator, with low temperature surface.

It heats air from 40 deg. below zero to 70 deg. or thru any equivalent range when the UNIVENT is in operation.

Univent Fan and Motor: A single aluminum low speed fan is used. No housing is necessary for this fan.

All models of UNIVENT can be equipped with direct or 60 cycle alternating current motors, and are recommended in the following order: Direct-current, polyphase, alternating current, single-phase alternating current.



Open View of UNIVENT Illustrating
A—Copper radiator without a single joint, absolutely leak-proof.
B—Air filter easily removable for cleaning.
C—Cone type fan specially insulated for quiet operation.

UNIVENT
(TRADE MARK)

Ventilation

Filter: Filters for removing dirt, dust, soot and sand from the air can be installed in the UNIVENT if desired. No nuts, bolts or screws are necessary for installation.

Automatic Temperature Control: Any well known system of temperature control may be used with the UNIVENT System.

Capacities: Four sizes of each model with capacities varying from 500 to 1500 cu. ft. of air per minute can be furnished.

Service Stations—Information: Representatives and Service men are located in each of the cities listed above.

Catalogs containing complete engineering data can be furnished on request to our main office at Moline, Illinois.

John J. Nesbitt, Inc.

Established 1894

Manufacturers of

The Universal Unit Ventilation System

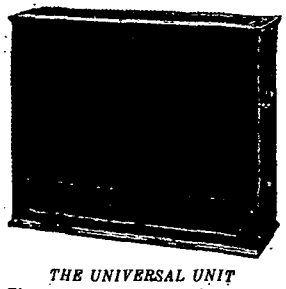
EXECUTIVE OFFICE AND FACTORY:
State Road and Rhawn St., Holmesburg Junction, Philadelphia, Pa.

Branch Office
NEW YORK CITY
JOHN J. NESBITT, INC., 405 Lexington Avenue

Sold by AMERICAN BLOWER COMPANY, Detroit, Mich., through following branch offices:

ATLANTA, GA., Allen Building
BALTIMORE, MD., American Building
BIRMINGHAM, ALA., American Trust Building
BOSTON, MASS., 10 High Street
BUFFALO, N. Y., White Building
CHARLOTTE, N. C., Piedmont Building
CHICAGO, ILL., 140 S. Dearborn Street
CINCINNATI, OHIO, Keith Building
CLEVELAND, OHIO, Swetland Building
COLUMBUS, OHIO, First National Bank Building
DALLAS, TEXAS, Mercantile Bank Building
DAVENPORT, IOWA, Kahl Building
DENVER, COLO., 228 California Street
DETROIT, MICH., 2539 Woodward Avenue
EL PASO, TEXAS, Border National Bank Building
GRAND RAPIDS, MICH., Shepard Building
INDIANAPOLIS, IND., Continental Bank Building
KANSAS CITY, MO., Mutual Building
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MILWAUKEE, WIS., Majestic Building
MINNEAPOLIS, MINN., 800-6 La Salle Avenue
NEW ORLEANS, LA., 521 Baronne Street
NEW YORK CITY, N. Y., 50 Church Street
OMAHA, NEB., Peters Trust Building
PHILADELPHIA, PA., Otis Building
PITTSBURGH, PA., Oliver Building
PORTLAND, ORE., Spaulding Building
ROCHESTER, N. Y., Cutler Building
SALT LAKE CITY, UTAH, Dooly Building
SAN FRANCISCO, CALIF., Rialto Building
SEATTLE, WASH., Leary Building
SCHENECTADY, N. Y., 147 Jay Street
ST. LOUIS, MO., Boatman's Bank Building
SYRACUSE, N. Y., 1611 E. Gennesee Street
TACOMA, WASH., 1127 St. Paul Avenue

Canadian Sirocco, Ltd.
MONTREAL, 144 Inspector Street
CALGARY, 605 W. Second Street
WINNIPEG, 567 Banning Street
VANCOUVER, 612 Standard Bank Building
WINDSOR, McDougall and Banwell Streets



THE UNIVERSAL UNIT
The Standard by Which All Other Makes are Measured
Trade Mark Reg. U. S. Pat. Office

Products

Manufacturers of the UNIVERSAL combined heating and ventilating Units. (Portable Unit ventilators), also UNIVERSAL air filters.

Universal Unit System of Heating and Ventilating

A mechanical system of ventilation for supplying fresh warm air directly from outdoors for use wherever good ventilation is required and particularly suitable for school house ventilation.

Universal Combined Heating and Ventilating Units

The cabinet of the UNIVERSAL UNIT is constructed of No. 14 gage cold rolled, stretched leveled, pickled and oiled first quality furniture stock steel. All parts of the UNIVERSAL UNIT are finished in olive green, sprayed and baked to a smooth hard finish.

Fans

UNIVERSAL Fans are of the multi-blade low speed double inlet type, designed to operate at 800 r.p.m., plus or minus 5 per cent. The fans are rigidly constructed of aluminum with special care given to balance. Fans are mounted on double extended ends of the motor shaft.

Motor

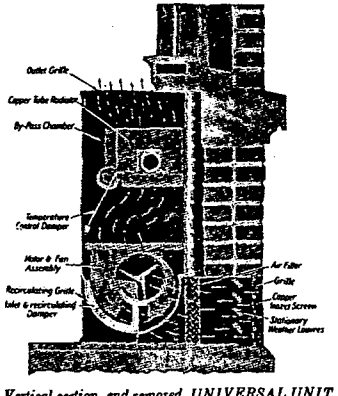
Motor of UNIVERSAL UNIT can be supplied for quiet operation on any character of current. The use of a motor generator set is no longer necessary with this system.

Three-Point Lead Mounting

The motor and fan, assembly of the UNIVERSAL UNIT is mounted in the cabinet on three steel ball points. These points rest on lead liners, supported by angles from the side of the casing. This three-point lead mounting has made possible the use of alternating current motors with a permanent and rigid supporting device.

Universal Unit Radiator

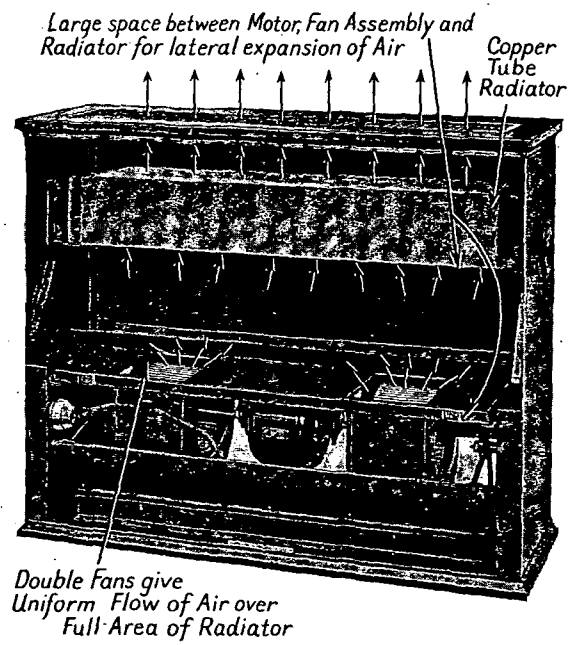
Standard UNIVERSAL UNITS are provided with 106.25 sq. ft. of prime surface, extruded copper tube radiation. The radiator weighs only 61 pounds complete. This radiator is composed of a plurality of individual, thin walled, seamless copper tubes the ends of which are hexagonal and assembled resemble a true honey-comb in appearance. The steam is free to flow between the tubes in both a vertical and horizontal direction. The air flows through the tubes, so that the tubes are entirely surrounded by steam on one side and swept by air on the other side, which means 100 per cent prime surface.



Vertical section, end removed, UNIVERSAL UNIT, Series No. 14-3643. Fresh air intake through wall box and grille near bottom of Unit. This Unit can be recessed to depth of 4 in. as shown, recess must be 60 in. long by 36 in. high, or can be recessed 8 in. in 43 in. long recess 36 in. high. Standard practice places the Unit flush with the inside wall.

Temperature Control Damper

The UNIVERSAL UNIT is provided with a temperature control damper, which can be manually or thermostatically operated to regulate the temperature of air from Unit.



UNIVERSAL UNIT Series No. 14-3643 one piece front and by-pass division plates removed, showing radiator and motor fan assembly in place. Entire operation of removing and replacing front and by-pass requires less than three minutes

Inlet and Recirculating Damper

Each UNIVERSAL UNIT is arranged so that air can be brought from outdoors, warm, if desired, and circulated in the room, or can be recirculated and reheated within the room, as desired. This is accomplished by means of a circular roll damper of aluminum. This damper can be manually controlled at the cabinet, or pneumatically controlled from some remote point.

Universal Air Filters

The use of air filters is especially recommended for buildings located in congested manufacturing districts, or where the air is heavily laden with dust or soot. UNIVERSAL air filters are of the adhesive impingement type, designed to fit in the fresh air intake of the UNIVERSAL UNIT. In this location the velocity of air over the entire surface of the filter is uniform with the result that an equal amount of work is imposed throughout its entire area. Combined with this ideal location is a set arrangement, which provides ease and simplicity of removal and replacement, when cleaning is necessary.

Catalog and Engineers' Data Book

A copy of our "*Catalog and Engineers' Data Book*," containing complete engineering data, specifications, etc. on UNIVERSAL UNIT Ventilation System, will be furnished upon request to our executive office.

TABLE OF CAPACITIES
Final Temperatures and Condensations

STEAM—218 DEG. 2 LBS. GAUGE

Temp. Entering Air Deg. F.	1500 Cu. Ft. of Air per Minute or 90,000 Cu. Ft. of Air per Hour—Universal Unit Series No. 14-3643-15 and 18-3643-15					1200 Cu. Ft. of Air per Minute or 72,000 Cu. Ft. of Air per Hour—Universal Unit Series No. 14-3643-12 and 18-3643-12				
	Final Temp. of Air	British Thermal Units	Sq. Feet Surface in Radiator	Condensation per Sq. Ft. in Rad.	Total Condensation in Radiator	Final Temp. of Air	British Thermal Units	Sq. Feet Surface in Radiator	Condensation per Sq. Ft. in Rad.	Total Condensation in Radiator
−10	100.31	210115	106.25	2.06	218.87	103.1	175440	106.25	1.72	182.75
0	106.63	201955	106.25	1.98	210.37	109.4	168297	106.25	1.65	175.31
10	112.65	192777	106.25	1.89	200.81	115.73	161155	106.25	1.58	167.87
20	119.28	183600	106.25	1.80	191.25	122.04	154012	106.25	1.51	160.43
30	125.63	175440	106.25	1.72	182.75	128.35	145852	106.25	1.43	151.93
40	131.93	166252	106.25	1.63	173.18	134.67	138720	106.25	1.36	144.50
50	138.23	157075	106.25	1.54	163.62	140.97	131577	106.25	1.29	137.06
60	144.43	148915	106.25	1.46	155.12	147.37	123417	106.25	1.21	128.56
70	150.83	139737	106.25	1.37	145.56	153.67	116275	106.25	1.14	121.12
Current Consumed Watts Hour	A. C. 146 Watts			D. C. 143 Watts		A. C. 118 Watts			D. C. 102 Watts	

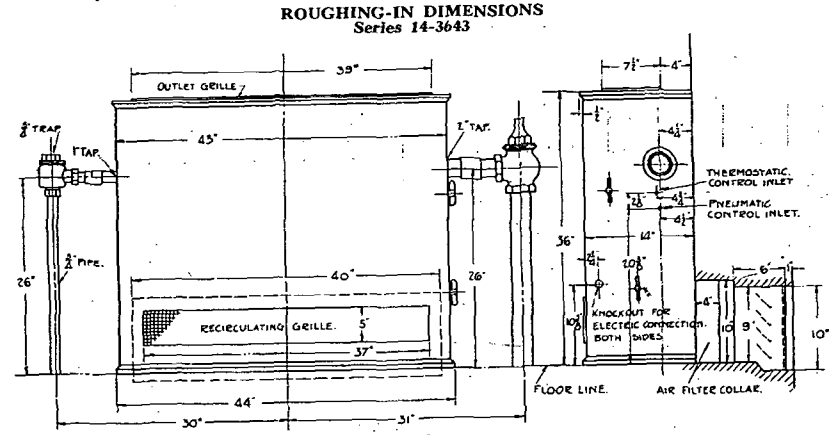
Temp. Entering Air Deg. F.	900 Cu. Ft. of Air per Minute or 54,000 Cu. Ft. of Air per Hour—Universal Unit Series No. 14-3643-9 and 18-3643-9					600 Cu. Ft. of Air per Minute or 36,000 Cu. Ft. of Air per Hour—Universal Unit Series No. 14-3643-6 and 18-3643-6				
	Final Temp. of Air	British Thermal Units	Sq. Feet Surface in Radiator	Condensation per Sq. Ft. in Rad.	Total Condensation in Radiator	Final Temp. of Air	British Thermal Units	Sq. Feet Surface in Radiator	Condensation per Sq. Ft. in Rad.	Total Condensation in Radiator
−10	112.96	139737	106.25	1.37	145.56	123.18	103017	106.25	1.01	107.31
0	119.3	133612	106.25	1.31	139.18	130.6	98937	106.25	0.97	103.06
10	125.64	128515	106.25	1.26	133.87	137.02	93840	106.25	0.92	97.75
20	131.98	122400	106.25	1.20	127.5	143.42	89760	106.25	0.88	93.50
30	138.28	116275	106.25	1.14	121.12	149.79	85680	106.25	0.84	89.25
40	144.68	110160	106.25	1.08	114.75	156.29	83635	106.25	0.82	87.12
50	150.98	105052	106.26	1.03	109.43	.....	.....	.....	....	.....
Current Consumed Watts Hour	A. C. 90 Watts			D. C. 90 Watts		A. C. 80 Watts			D. C. 83 Watts	

When a fine adjustment is desired for obtaining either a smaller or larger volume of air than a given set of fans discharge from a given line voltage, air volume regulators will be furnished.

The air volume regulators consist of curved plates, which may be readily adjusted to further open or close the fan discharge opening.

The adjustment of these plates for a smaller air delivery reduces the amount of current consumed.

ROUGHING-IN DIMENSIONS
Series 14-3643

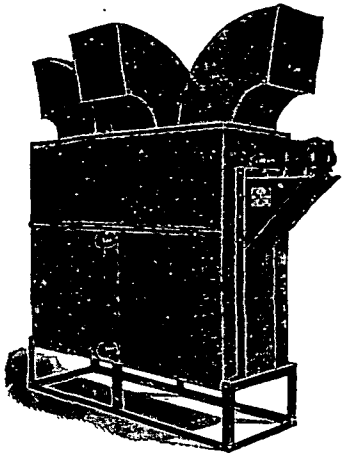


York Heating and Ventilating Corp.

1502 Locust Street :: PHILADELPHIA

Unit Heaters—Unit Fans—Rotary Ventilators—Stationary Ventilators—Cyclone Dust Collectors—Damper Quadrants—Blast Gates—Drying Trays—Radiator Brackets—Sheet Metal Work and Light Structural Iron Fabrication.

YORK "WELDED COIL" UNIT HEATER



OPERATION

Air enters the unit at the base from all four sides, passes upward around the welded pipe coils, through the fan and is then distributed by the outlets in any direction desired. Unit may be automatically controlled by a thermostatic switch.

OPERATING ECONOMIES

It is not necessary to run YORK UNIT HEATERS continuously to obtain an appreciable amount of heat, as is the case with horizontal unit heaters or a blower system. In the morning the units can be run for a short time to bring the room up to the proper temperature and to start the air in circulation. The power can then be shut off and the circulation thus started will continue (although at a slower rate).

SPECIAL FEATURES

The coils are welded entirely, therefore there are no joints to leak.

The coils are guaranteed for operation up to 200 lbs. steam pressure and are tested to 1000 lbs. hydrostatic pressure.

All eight sizes of YORK UNITS are designed for standard motors operating at standard speeds.

Direct connection to motors by flexible couplings is supplied at less cost than belt or chain drive.

Full housed centrifugal fans of the double inlet type give the high outlet velocity so essential to positive distribution.

Self-aligning, dust-proof ball bearings are standard for fan shaft mounting.

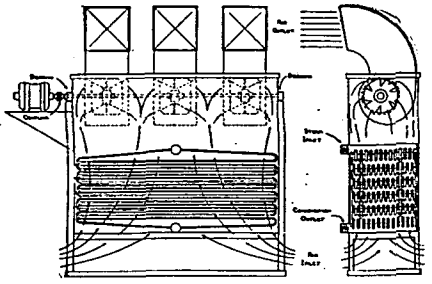
Units are narrow in width, permitting unobtrusive placing in the shop.

Operates equally well on vacuum, low or high pressure steam.

Unit will heat and ventilate simultaneously, if desired.

Base of the unit is open on all four sides, hence air is drawn from the floor, where it is naturally coldest. This simplifies connection to outside air when same is desired, for it can easily be made by a rectangular duct from any one side.

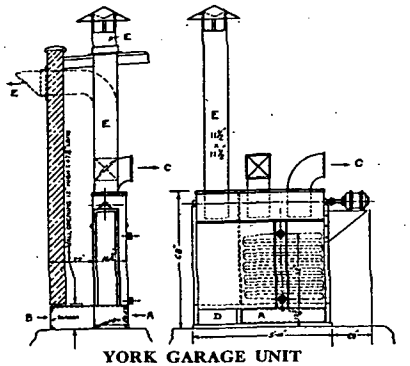
Rigid discipline in manufacturing assures unfailing and economical operation from units so carefully designed.



Capacities and Dimensions

Size Unit	R.P.M.	A.P.M.	H.P. Motor	Recirculating Air at 60° F. Entering Unit: B.t.u.*	Final Temp.	Lbs. Cond. per Hr.	Sq. Ft. Heating Surface	Equiv. Direct Radiation	Weight with Motor	A	B	C	D	X	H	No. of Outlets
25	1750	2780	¾	208,000	137.5°	217	140	830	1100	47	17	16	86	11⅜	14	2
	1160	1800	⅓	147,000	146.0°	153										
35	1750	5480	1½	411,000	137.8°	428	280	1650	1900	88	17	20	86	11⅜	14	4
	1160	3620	½	296,500	146.3°	309										
45	1450	9650	5	676,000	132.0°	707	360	2300	2450	88	30	24	113	18⅜	20	2
	870	5850	1	462,000	142.5°	481										
50	1450	10950	7½	741,000	129.2°	772	360	2520	2500	88	30	24	113	18⅜	20	3
	870	6550	1½	504,000	140.2°	525										
55	1450	12800	7½	950,000	136.8°	990	520	3200	3300	88	30	24	113	18⅜	20	3
	870	7700	2	635,000	147.0°	661										
60	1450	14360	10	1,037,000	134.5°	1080	520	3500	3400	88	30	26	113	19⅛	20	3
	870	8600	2	694,000	144.5°	723										

*NOTE—To get BASIC Rating (i.e., 0 entering and 5 lb. pressure), multiply B.t.u. given by 1.35. See 1924 GUIDE, page 339, for B.t.u. Constants.



YORK GARAGE UNIT

A—Damper that permits recirculating air in building.
B—Fresh air opening, which is closed when damper A is opened. Outside opening protected by wire screen.
C—Warm air outlets. Since they have a square base they may be pointed in other directions than those shown.
D—Opening at floor line for entrance of exhaust gases.
E—Duct for discharging exhaust gases to outdoors.

The above is standard arrangement for motor, exhaust air outlet and steam headers but their relative position can be reversed if conditions require.

RATINGS No. 30-G UNIT For Steam Pressure of 5 Pounds

R. P. M.	Cu. Ft. per Min. Warm Air	H. P. Motor	Recirculating Air at 60 Deg. Fahr. Entering Unit: B.t.u. per Hr.	Final Temp.	Cond. per Hr.	Basic Data Air at 0 Deg. Fahr. Entering Unit: B.t.u. per Hr.	Final Temp.	Cond. per Hr.	Cu. Ft. Air per Min. Exhausted
1750	2780	1½	208,000	137.5°	217#	281,000	104.8°	294#	1700
1450	2290	1	178,200	141.3°	186#	241,000	109.9°	252#	1410
1160	1800	½	147,000	146.0°	153#	198,600	116.1°	207#	1130
870	1340	¼	116,100	152.0°	121#	157,000	124.2°	164#	850

May be used on high or low pressure steam, vapor, vacuum or hot water system.

YORK WELDED COIL UNIT, No. 30-G

This self-contained unit combines the means for heating and ventilating garages and exhausting foul gases.

The air to be warmed is drawn through the heating coils by two (2) of the fans, and discharged positively in desired directions. This air may be drawn fresh from out-of-doors, or recirculated within the buildings at will by a regulation of dampers.

The third fan, with its intake at the floor level, withdraws and exhausts to the outside the poisonous gases that collect along the floor when motors are run.

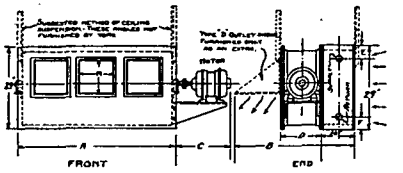
When a number of engines are running and throw off an objectionable quantity of gases, the exhaust pipe damper and fresh air damper are opened. The garage will then be quickly ventilated. At times when little or no gases are produced, the exhaust pipe damper may be closed and the recirculating damper opened. The heater then recirculates the air within the building, so that fuel is saved when no ventilation is needed.

When more heating capacity is needed than that provided by the units necessary for ventilation, unit heaters without the exhaust fan are added to complete the required total.

Garage Unit No. 32-G has the same B.t.u. capacity as the No. 30-G but twice the exhaust capacity and requires a 2 h.-p. motor for 1750, a 1½ h.-p. for 1450 and a 1 h.-p. for 1160 r.p.m.

Dimensions are the same as No. 35 unit on opposite page.

YORK-FIN UNIT For Steam Pressures up to 15 lbs.



Note—When facing outlet openings, RH means motor is on Right; LH means motor is on left. Unless otherwise specified, RH will be furnished.

APPLICATION

Recommended only for plants with overhead returns fed by low pressure supply. York Welded Coil, Floor Mounted Unit Heaters are preferable for all other conditions.

Ratings, Specifications and Dimensions

Size Unit	R. P. M.	A. P. M.	H. P. Motor	Recirculating Air at 60° F. Entering Unit and 5# Steam Press.: B.t.u.	Final Temp.	Cond. per Hr.	Sq. Ft. Heating Surface: Actual	Equiv. Direct Radiation	Outlet Openings: No.	N x N Outside of Angles	Weight Complete With Motor, Lbs.	Dimensions: A	B	C	D	E	F	Size Supply	Size Return
102	1750	3000	¾	157,000	112.0°	164#	109	630	2	11¼ x 11¼	370	33	43	16	15	3⅜	3⅜	2"	2"
	1160	2000	¼	116,500	118.5°	121#													
103	1750	4100	1	231,500	116.5°	241#	164	930	3	11¼ x 11¼	460	45	43	20	15	3⅜	3⅜	3"	2"
	1160	2710	⅓	172,000	124.3°	179#													
104	1750	6200	1½	381,000	122.0°	397#	246	1520	4	11¼ x 11¼	550	63	43	20	15	3⅜	3⅜	3"	2"
	1160	4100	½	270,000	127.2°	281#													
162	1160	7800	3	433,000	115.4°	452#	273	1740	2	18¼ x 18¼	750	69	61	25	22½	3⅜	3⅜	3"	2"
	870	5880	1	358,000	121.3°	373#													

Pecco Incorporated

Main Office and Factory
2951 North Market Street ST. LOUIS, MISSOURI, U. S. A.



District Sales Offices

DAVENPORT, IOWA—1608 E. Tenth Street
COLUMBUS, OHIO—404 Clinton Building
CINCINNATI, OHIO—919 Provident Bank Building
BALTIMORE, MD.—109 E. Pleasant Street
BOSTON, MASS.—162 Tyler Street
CHICAGO, ILL.—5530 Cornell Avenue
MILWAUKEE, WIS.—137 Oneida Street
PITTSBURGH, PA.—Farmers' Bank Building

PECCO UNIT HEATERS

PECCO UNIT HEATERS are built in two types—Steam Coil and Direct Fired.

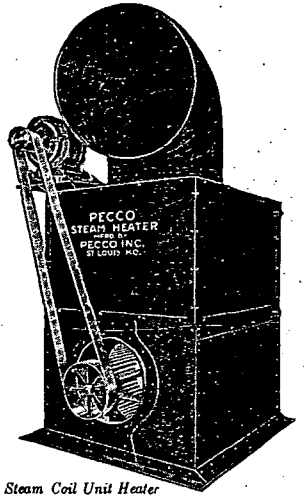
The particular advantages of these units lie in the fact that they are designed entirely on fundamental principles of aerodynamics.

Cold air intake (see illustration) is located at the bottom near the floor or cold air level.

The warm air outlet hood (through which the warm air is projected by the bank of steam coils placed directly over the fan wheel) is located at the warm air or breathing level.

In operation the cold air is exhausted by the fan wheel, forced upward and around the steam coils, heated by the steam coils and then projected at the breathing level.

A thorough **recirculation** of air is thus established and because the fan wheel keeps the heated air always in movement, it is distributed evenly throughout the open building space.

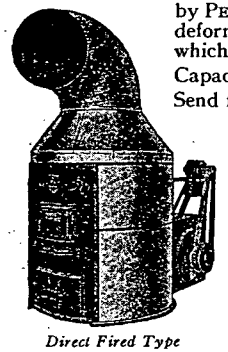


Steam Coil Unit Heater

Mechanically, PECCO UNIT HEATERS are built to highest standards and in many instances include features which were developed and used exclusively by PECCO. The steam coils are made of heavy pipe bent cold without deformation at the bend and butt-jointed with special steel couplings which prevent rupture and subsequent leakage.

Capacity ranges from 135,000 to 1,550,000 B.t.u.'s per unit.

Send for complete catalog.



Direct Fired Type

Direct Fired Type

The illustration at the left shows the PECCO DIRECT FIRED UNIT, which burns either coal, coke, gas, wood or oil. Built on the same principle, this type is as effective as the Steam Coil Type.

Send for special catalog.

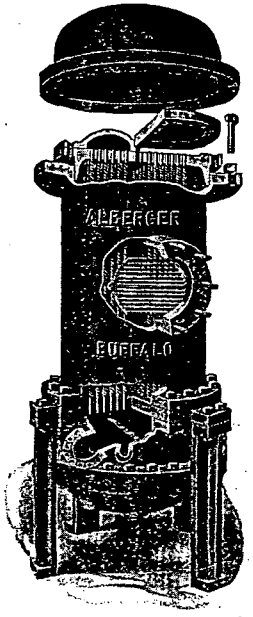
In addition to the above, PECCO, INCORPORATED, also manufactures the so-called ceiling suspension copper fin type heaters and complete blow pipe systems.

Special Engineering service gladly furnished.

Alberger Heater Company

HOWARD IRON WORKS
218 Chicago St. :-: :-: :-: BUFFALO, N. Y.
REPRESENTATIVES IN PRINCIPAL CITIES

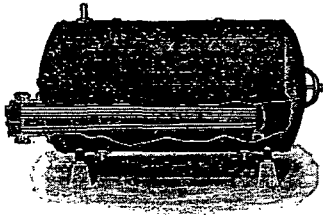
Heaters — Condensers — Coolers — Economizers — Expansion Joints



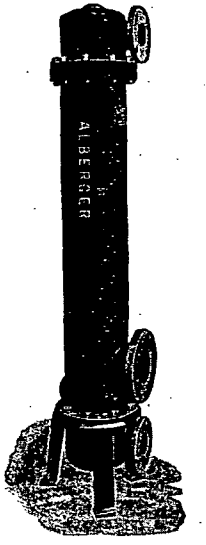
Instantaneous Water Heater Furnished in Vertical or Horizontal Type

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.



Storage Type Heater

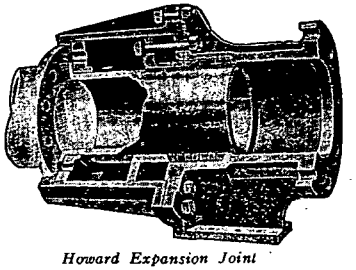


Swimming Pool Heater Single Pass Furnished in Vertical or Horizontal Type

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.

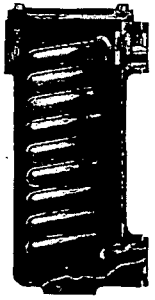


Howard Expansion Joint

Excelso Specialty Works, Inc.

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

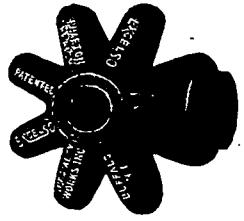
Size	Jr.	11	12	13	14	15	25	26	27	28	35	36
Tank Capacity	30	30	45	60	90	120	160	200	300	400	600	800

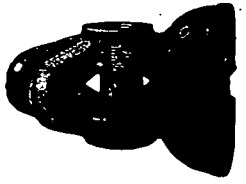
Temperature rise 100 deg. in 3 hours.

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.



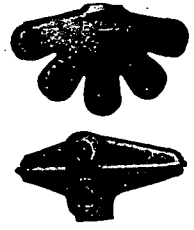


THE EXCELSO PHAETON HEATER

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 three sizes: 1 in., 1½ in. and 2 in. Pipe Tap size.

Price $7.50 net, with six blades; two of each size.

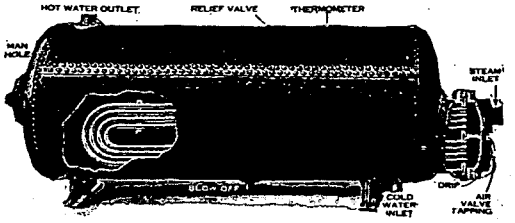
The Patterson-Kelley Co.

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 45 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.

O. E. Frank Heater and Engineering Co., Inc.

Associated with FARRAR & TREFTS, Inc.

BUFFALO, N. Y.

Branch Offices

NEW YORK — INDIANAPOLIS
PHILADELPHIA — KANSAS CITY
DETROIT — CHARLOTTE, N. C.
ST. LOUIS — CALGARY, ONT.

Branch Offices

BOSTON MASS. — MINNEAPOLIS
CHICAGO — SAN FRANCISCO
PITTSBURGH — WASHINGTON
CLEVELAND — HARRISBURG, PA.

O. E. F. products consist of a complete line of heaters for every hot water need. Storage Heaters for hot water service in either U-tube or Straight tube type. Instantaneous Heaters for hot water service, heating systems, power plants. Complete information on materials, construction, service and our guarantee on request.

Large stocks of tanks, castings and tubes insure prompt shipments.

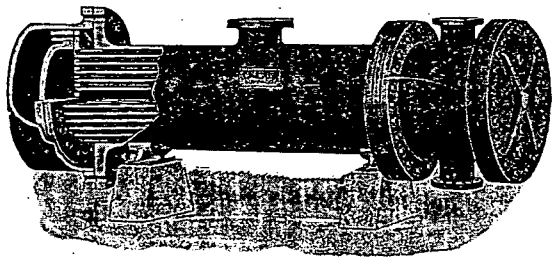
Capacities and General Dimensions O. E. F. Instantaneous Heaters, Heating Water from 50 to 180° F. with Steam at 212° F.

Gals. per Hr.	Size	Approx. Overall Dimensions: Width	Length Hor. Type	Height Ver. Type	Max. Steam	Max. Water	Drain	Gals. per Hr.	Size	Approx. Overall Dimensions: Width	Length Hor. Type	Height Ver. Type	Max. Steam	Max. Water	Drain
200	IH-7	15¾″	7′-5″	8′-11½″	3″	3″	1″	2000	IH-60	21¾″	8′-8¾″	9′-8¾″	4″	5″	1½″
300	IH-11	15¾″	7′-5″	8′-11½″	3″	3″	1″	2500	IH-76	25¾″	8′-11″	9′-10″	6″	6″	2″
400	IH-14	15¾″	7′-5″	8′-11½″	3″	3″	1″	3000	IH-90	25¾″	8′-11″	9′-10″	6″	6″	2″
500	IH-15	18″	8′-7″	9′-8″	3″	4″	1½″	4000	IH-120	26½″	9′-1¾″	10′-4¼″	8″	8″	3″
600	IH-18	18″	8′-7″	9′-8″	3″	4″	1½″	5000	IH-150	26½″	9′-1¾″	10′-4¼″	8″	8″	3″
800	IH-24	18″	8′-7″	9′-8″	3″	4″	1½″	6000	IH-162	26½″	9′-1¾″	10′-4¼″	8″	8″	3″
1000	IH-30	18″	8′-7″	9′-8″	3″	4″	1½″	7000	IH-189	30¼″	10′-3¼″	11′-4¼″	10″	8″	3″
1250	IH-38	18″	8′-7″	9′-8″	3″	4″	1½″	8000	IH-216	30¼″	10′-3¼″	11′-4¼″	10″	8″	3″
1500	IH-45	21¾″	8′-8¾″	9′-8¾″	4″	5″	1½″	9000	IH-243	30¼″	10′-3¼″	11′-4¼″	10″	8″	3″
1800	IH-54	21¾″	8′-8¾″	9′-8¾″	4″	5″	1½″	10000	IH-270	30¼″	10′-3¼″	11′-4¼″	10″	8″	3″

Capacities and General Dimensions O. E. F. Feed Water Heaters, Heating Feed Water from 50 to 200° F. with Steam at 212° F.

Horse Power	Size	Lbs. per Hour	Approximate Overall Dimensions: Width	Length Horiz. Type	Height Vertical Type	Maximum Steam	Maximum Water	Drain
50	FW-9	1500	15¾″	7′-5″	8′-11½″	3″	3″	1″
75	FW-13	2250	15¾″	7′-5″	8′-11½″	3″	3″	1″
100	FW-17	3000	15¾″	7′-5″	8′-11½″	3″	3″	1″
150	FW-26	4500	18″	8′-7″	9′-8″	3″	4″	1½″
200	FW-35	6000	18″	8′-7″	9′-8″	3″	4″	1½″
250	FW-43	7500	21¾″	8′-8¾″	9′-8¾″	4″	5″	1½″
300	FW-52	9000	21¾″	8′-8¾″	9′-8¾″	4″	5″	1½″
350	FW-61	10500	21¾″	8′-8¾″	9′-8¾″	4″	5″	1½″
400	FW-69	12000	21¾″	8′-8¾″	9′-8¾″	4″	5″	1½″
450	FW-78	13500	25¼″	8′-11″	9′-10″	6″	6″	2″
500	FW-87	15000	25¼″	8′-11″	9′-10″	6″	6″	2″
600	FW-104	18000	25¼″	8′-11″	9′-10″	6″	6″	2″
700	FW-121	21000	26½″	9′-1¾″	10′-4¼″	8″	8″	2″
800	FW-136	24000	26½″	9′-1¾″	10′-4¼″	8″	8″	2″
900	FW-156	27000	26½″	9′-1¾″	10′-4¼″	8″	8″	2″
1000	FW-160	30000	26½″	10′-1¾″	11′-4¼″	8″	8″	2″
1100	FW-165	33000	26½″	10′-1¾″	11′-4¼″	8″	8″	2″
1200	FW-180	36000	26½″	10′-1¾″	11′-4¼″	8″	8″	2″
1300	FW-195	39000	30¼″	10′-3¾″	11′-8¼″	10″	8″	3″
1400	FW-210	42000	30¼″	10′-3¾″	11′-8¼″	10″	8″	3″
1500	FW-225	45000	30¼″	10′-3¾″	11′-8¼″	10″	8″	3″
1800	FW-270	54000	30¼″	10′-3¾″	11′-8¼″	10″	8″	3″
2000	FW-300	60000	34¼″	11′-0¼″	12′-0¼″	10″	10″	3″
2500	FW-375	75000	34¼″	11′-0¼″	12′-0¼″	10″	10″	3″
3000	FW-450	90000	39¼″	11′-6¼″	12′-6¼″	10″	12″	3″
4000	FW-600	12000	39¼″	11′-6¼″	12′-6¼″	10″	12″	3″

O. E. F. Feed Water Heaters and Instantaneous Heaters are designed for a maximum working pressure of 125 lbs. on the water spaces and 50 lbs. on the steam spaces.



O. E. F. Instantaneous Heaters are constructed of heavy close grain castings with rolled steel tube sheets and eighteen gage Admiralty Metal tubes. Admiralty Metal tubes are unexcelled for feed-water service. Write us about them.

O. E. F. Instantaneous Heater for General Hot Water Service, Feed Water, Bleeder Turbines and Forced and Gravity Hot Water Heating Systems. Also Vertical Type. Steam opening may be located on top or either side of shell to suit requirements.

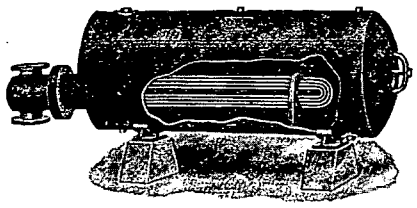


Fig. 1. O. E. F. U-Tube Storage Heater

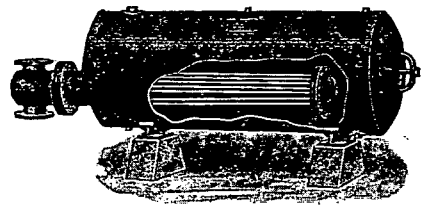


Fig. 7. O. E. F. Straight Tube Storage Heater

O. E. F. Storage Heaters are made of best quality flange steel, have rolled steel tube sheets, and sixteen gage copper tubes. Chemical analysis and physical test of all steel used furnished on request. O. E. F. Heaters are doubly guaranteed by O. E. Frank Heater & Engineering Company and Farrar & Trefts, Inc.

O. E. F. Storage Heaters are furnished in either the U-bend Pattern, per Fig. 1 or the Straight Tube type, per Fig. 7. The shells are of best quality steel plate, the smaller sizes welded and the larger sizes riveted construction. The heating surface consists of 1¼ in. OD seamless drawn copper tubes No. 16 or 18 SWG as required. They are properly supported with a tube supporting plate to prevent wear of the tubes due to sagging and rubbing together. The tube sheets are steel, eliminating any possibility of cracks and leaks, which so commonly occur with cast iron tube sheets. The tube nests or bundles are removable from the tank for cleaning or repairing.

Where it is necessary to use both low and high pressure steam, the steam chamber and tubes may be arranged without the necessity of installing a separate tube bundle.

Openings of ample size are provided, and we call your attention to the arrangement of the steam inlet and outlet, making it possible to remove the tube bundle by simply unbolting the flanges and avoiding the necessity of breaking any length of pipe.

All storage heaters, unless otherwise specified, will be furnished for a working pressure of 100 pounds per square inch gage pressure, on both the steam and water spaces.

Storage heaters furnished for higher pressures.

CAPACITIES—O. E. F. U-Tube and Straight Tube Storage Heaters—Heating Given Quantities of Water from 50-180 Deg. Fahr. with Steam at 212 Deg. Fahr.

Storage Capacity	80	93	141	164	188	220	257	294	330	370	423	476	529	576	648	720	792	864	752	846	940
Tank Size	18x72	18x84	24x72	24x84	24x96	30x72	30x84	30x96	30x108	36x84	36x96	36x108	36x120	42x96	42x108	42x120	42x132	42x144	48x96	48x108	48x120
Gallons per Hour																					
100	A5	B5	C5	D5	E5	F5	G5	H5	J5	K5	L5	M5	N5	O5	P5	Q5	R5	S5	T5	V5	W5
200	A11	B11	C11	D11	E11	F11	G11	H11	J11	K11	L11	M11	N11	O11	P11	Q11	R11	S11	T11	V11	W11
300	.....	B16	C16	D16	E16	G16	H16	J16	K16	L16	M16	N16	O16	P16	Q16	R16	S16	T16	V16	W16	
400	.....	.....	C22	D22	E22	G22	H22	J22	K22	L22	M22	N22	O22	P22	Q22	R22	S22	T22	V22	W22	
500	.....	.....	C27	D27	E27	F27	G27	H27	J27	K27	L27	M27	N27	O27	P27	Q27	R27	S27	T27	V27	W27
600	.....	.....	C32	D32	E32	F32	G32	H32	J32	K32	L32	M32	N32	O32	P32	Q32	R32	S32	T32	V32	W32
700	.....	.....	C38	D38	E38	F38	G38	H38	J38	K38	L38	M38	N38	O38	P38	Q38	R38	S38	T38	V38	W38
800	.....	.....	.....	D43	E43	F43	G43	H43	J43	K43	L43	M43	N43	O43	P43	Q43	R43	S43	T43	V43	W43
900	.....	.....	.....	D47	E47	F47	G47	H47	J47	K47	L47	M47	N47	O47	P47	Q47	R47	S47	T47	V47	W47
1000	.....	.....	.....	.....	E54	F54	G54	H54	J54	K54	L54	M54	N54	O54	P54	Q54	R45	S54	T54	V54	W54
1500	.....	.....	.....	.....	.....	F81	G81	H81	J81	K81	L81	M81	N81	O81	P81	Q81	R81	S81	T81	V81	W81
2000	.....	.....	.....	.....	.....	.....	G108	H108	J108	K108	L108	M108	N108	O108	P108	Q108	R108	S108	T108	V108	W108
2500	.....	.....	.....	.....	.....	.....	.....	.....	J134	.....	.....	M134	N134	O134	P134	Q134	R134	S134	T134	V134	W134
3000	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	N162	O162	P162	Q162	R162	S162	T162	V162	W162
4000	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	P215	Q215	R215	S215	T188	V188	W188
5000	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	R269	S269	.....	V215	W215

Storage Cap.	1034	1128	1204	1325	1445	1574	1666	1469	1616	1763	1909	2056	2115	2327	2538	2750	2961	3173
Tank Size	48x132	48x144	54x120	54x132	54x144	54x156	54x168	60x120	60x132	60x144	60x156	60x168	72x120	72x132	72x144	72x156	72x168	72x180
Gals. per Hr.																		
100	X5	Y5	AX5	BX5	CX5	DX5	FX5	GX5	HX5	KX5	LX5	MX5	NX5	OX5	PX5	QX5	RX5	TX5
200	X11	Y11	AX11	BX11	CX11	DX11	FX11	GX11	HX11	KX11	LX11	MX11	NX11	OX11	PX11	QX11	RX11	TX11
300	X16	Y16	AX16	BX16	CX16	DX16	FX16	GX16	HX16	KX16	LX16	MX16	NX16	OX16	PX16	QX16	RX16	TX16
400	X22	Y22	AX22	BX22	CX22	DX22	FX22	GX22	HX22	KX22	LX22	MX22	NX22	OX22	PX22	QX22	RX22	TX22
500	X27	Y27	AX27	BX27	CX27	DX27	FX27	GX27	HX27	KX27	LX27	MX27	NX27	OX27	PX27	QX27	RX27	TX27
600	X32	Y32	AX32	BX32	CX32	DX32	FX32	GX32	HX32	KX32	LX32	MX32	NX32	OX32	PX32	QX32	RX32	TX32
700	X38	Y38	AX38	BX38	CX38	DX38	FX38	GX38	HX38	KX38	LX38	MX38	NX38	OX38	PX38	QX38	RX38	TX38
800	X43	Y43	AX43	BX43	CX43	DX43	FX43	GX43	HX43	KX43	LX43	MX43	NX43	OX43	PX43	QX43	RX43	TX43
900	X47	Y47	AX47	BX47	CX47	DX47	FX47	GX47	HX47	KX47	LX47	MX47	NX47	OX47	PX47	QX47	RX47	TX47
1000	X54	Y54	AX54	BX54	CX54	DX54	FX54	GX54	HX54	KX54	LX54	MX54	NX54	OX54	PX54	QX54	RX54	TX54
1500	X81	Y81	AX81	BX81	CX81	DX81	FX81	GX81	HX81	KX81	LX81	MX81	NX81	OX81	PX81	QX81	RX81	TX81
2000	X108	Y108	AX108	BX108	CX108	DX108	FX108	GX108	HX108	KX108	LX108	MX108	NX108	OX108	PX108	QX108	RX108	TX108
2500	X134	Y134	AX134	BX134	CX134	DX134	FX134	GX134	HX134	KX134	LX134	MX134	NX134	OX134	PX134	QX134	RX134	TX134
3000	X162	Y162	AX162	BX162	CX162	DX162	FX162	GX162	HX162	KX162	LX162	MX162	NX162	OX162	PX162	QX162	RX162	TX162
3500	X188	Y188	AX188	BX188	CX188	DX188	FX188	GX188	HX188	KX188	LX188	MX188	NX188	OX188	PX188	QX188	RX188	TX188
4000	X215	Y215	AX215	BX215	CX215	DX215	FX215	GX215	HX215	KX215	LX215	MX215	NX215	OX215	PX215	QX215	RX215	TX215
4500	X243	Y243	AX243	BX243	CX243	DX243	FX243	GX243	HX243	KX243	LX243	MX243	NX243	OX243	PX243	QX243	RX243	TX243
5000	X269	Y269	.....	BX269	CX269	DX269	FX269	.....	HX269	KX269	LX269	MX269	.....	OX269	PX269	QX269	RX269	TX269
6000	.....	.....	.....	.....	.....	DX323	FX323	.....	.....	.....	LX323	MX323	.....	.....	.....	QX323	RX323	TX323
7000	.....	.....	.....	.....	.....	.....	FX377	.....	.....	.....	.....	MX377	.....	.....	.....	.....	RX377	TX377

Note.—The letter given in the above table of sizes indicates the size of the tank and the numerals the square feet of heating surface. *Example.*—A C5 heater consists of a 24″ x 72″ storage tank (length not including dished heads) and contains 5 sq. ft. of heating surface.

The Whitlock Coil Pipe Company

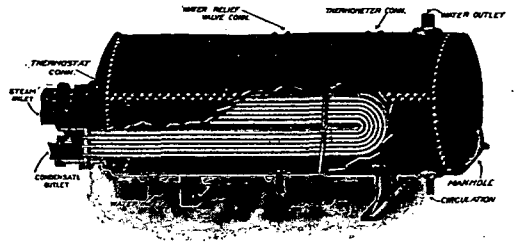
Manufacturers and Engineers

HARTFORD, CONN.

Baltimore, Md.	Denver, Colo.		New Orleans, La.	San Francisco, Calif.
Boston, Mass.	Des Moines, Iowa		New York, N. Y.	Seattle, Wash.
Buffalo, N. Y.	Detroit, Mich.	WHITLOCK HEAT TRANSFER PRODUCTS	Omaha, Neb.	St. Louis, Mo.
Charlotte, N. C.	Houston, Tex.		Philadelphia, Pa.	St. Paul, Minn.
Chicago, Ill.	Indianapolis, Ind.		Pittsburgh, Pa.	Tacoma, Wash.
Cincinnati, O.	Kansas City, Mo.		Portland, Ore.	Troy, New York
Dallas, Tex.	Memphis, Tenn.		Rochester, N. Y.	Tulsa, Okla.
			San Antonio, Tex.	

Darling Bros. Montreal, Manufacturers of Whitlock Heaters in Canada

See Telephone Directory for Local Address



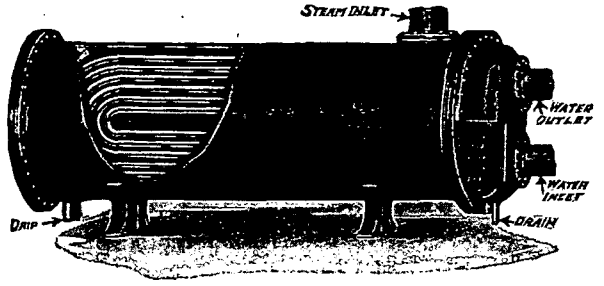
Whitlock type "K" storage heaters are manufactured in both horizontal and vertical types. The table shows sizes of the horizontal heaters only. We will gladly furnish dimensions of horizontal heaters and vertical heaters upon request. That this type of heater is of particularly sturdy construction is 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	3/8	5/8	4300	H25	5400	10	36x108	1300
27	1710	60	144	3/8	5/8	4900	H26	6000	10	36x120	1380
28	2000	60	168	3/8	5/8	5600	H27	7000	12	42x 96	1950
29	2300	60	192	3/8	5/8	6200	H28	8000	12	42x 96	2000
30	2460	72	144	3/8	5/8	5700	H29	9000	12	42x108	2300
31	2880	72	168	3/8	5/8	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

	2 PASS, TEMP. RANGE 40° F. to 80° F.						4 PASS, TEMP. RANGE 40° F. to 120° F.					
Size No.	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 3/8	7	1 1/4	1 1/2	90	150	16 3/8	7	3/4	1 1/4	100
2	650	19 3/8	7	1 1/2	1 1/2	110	300	21 3/8	7	1	2	115
3	1100	23 3/8	7	2	2	130	480	26 3/8	7	1	2	135
4	1600	29 3/8	7	2	2 1/2	145	650	31 3/8	7	1 1/4	2 1/2	150
5	1900	34 3/8	7	2	3	170	800	38 3/8	7	1 1/4	2 1/2	170
6	2550	24 3/4	9 1/2	2 1/2	3	240	960	24 1/4	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 1/4	9 1/2	2	3	270
8	3800	35 3/4	9 1/2	2 1/2	4	300	1600	35 1/4	9 1/2	2	3 1/2	300
9	5100	43 3/4	9 1/2	3	5	360	2100	43 1/4	9 1/2	2	4	350
10	6350	55 3/4	9 1/2	3	5	420	2600	55 1/4	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 7/8	20	5	10	2020
18 1/2	44400	70 7/8	20	8	12	2100	18500	82 7/8	20	5	12	2230
19	50700	78 7/8	20	8	12	2300	21000	92 7/8	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.

AEROFIN CORPORATION

750 Frelinghuysen Avenue
Newark, N.J.
L. C. SOULE, Sec'y and Chief Engineer

Manufacturers of

AEROFIN

Fan System Heating and Cooling Surface

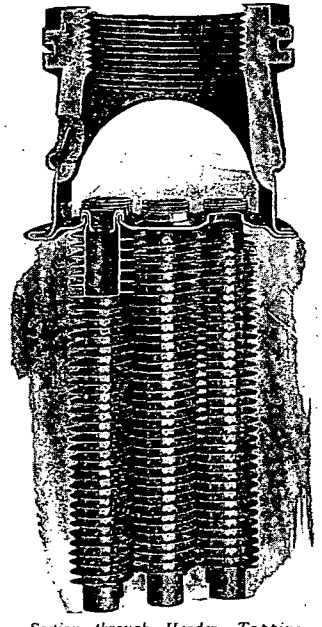
Type of Heater

AEROFIN Standard Units (except for the galvanized casings) are constructed entirely of brass and copper. The seamless copper tubes (⅝ in. O. D.) are wound with a helical crimped brass fin which is mechanically soldered to the tube while the fin is held tightly in place, so that a perfect metallic union is effected providing an excellent conducting medium for the heat. The fin surface is 80 per cent of the total surface, thereby effecting remarkable lightness in weight and great compactness.

Construction Advantages

The superiority of AEROFIN is demonstrated by its light-weight, non-corrosive features, unit construction, space saving, and because it comes to the job already encased and ready for steam connections. AEROFIN is furnished in various sizes of standard units which may be bolted together to make batteries of any number of units, wide, high, or deep (in the direction of air flow).

Our catalogue will be gladly sent on request to any architect, engineer, or contractor desiring same for the purpose of specifying exact sizes of AEROFIN UNITS or for obtaining complete information regarding the construction and installation of these units.



Section through Header, Tapping Hub, Tube Plate, Orifice Ring and Tubes, showing construction of AEROFIN

Weight

AEROFIN weighs from 9 to 16 per cent of equivalent cast-iron heaters and from 12 to 25 per cent of equivalent pipe coil heaters.

Two men can easily handle any of these AEROFIN Units.

Compactness

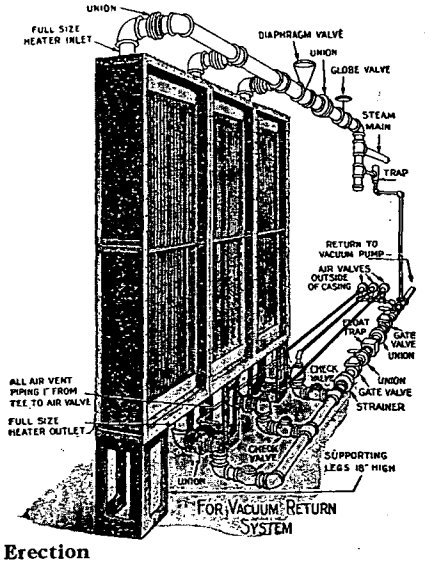
Several units may be assembled together like a sectional bookcase by simply bolting through the template-punched flanges.

AEROFIN Units are furnished in tube lengths ranging from 2 ft. to 12 ft. and with either one, two or three rows of tubes deep in each unit. There is only one standard size of header which makes the width of the units 29 in. over the casing flanges. The length of the casing is the tube length plus 8½ in.

AEROFIN batteries have about the same face area as is required by other blast heaters, but a great deal of space is saved in the direction of air flow. The 3-row units occupy only ⅓ the depth of that required by other heaters, 2-row units save ⅓ the depth and the single row units have the same 10 in. depth as is required for other types of heaters.

The galvanized steel casing with its template-punched flanges provides a means for direct attachment of the duct work or for the fastening of another set of batteries onto the back or front of the first battery, by simply bolting through the flanges.

For Diaphragm Valve Control see Chapter on Temperature Regulation in AEROFIN Catalog



Comparative Installation Costs

The installed cost for AEROFIN is generally less than that for other types of heaters, when the saving in erection and freight is considered. The factory cost of AEROFIN (completely encased) sometimes appears higher than the factory cost of other heaters (quoted without casing).

In figuring installation costs, add to the price of cast-iron heaters and pipe coils an additional 6 or 7 cents per sq. ft. of heating surface for the galvanized steel casing. AEROFIN has its galvanized steel casing as an integral part of the unit. **The average *labor cost* for installing cast-iron heaters and pipe coils is 12 to 25 cents per sq. ft. of heating surface, while the *labor cost* is only 3 to 5 cents per foot for installing AEROFIN. Remember that all sizes of AEROFIN Units can be handled by two men, without block and tackle.**

Erection

AEROFIN is so light and sturdily encased that it can easily be supported on steel legs which are furnished as a standard accessory at a small charge.

No extra reinforcement of the building construction required with AEROFIN—may be suspended from ceiling with small angles and rods, without expensive platforms—may be handled with only ordinary care and assembled without using any block and tackle or scaffolding.

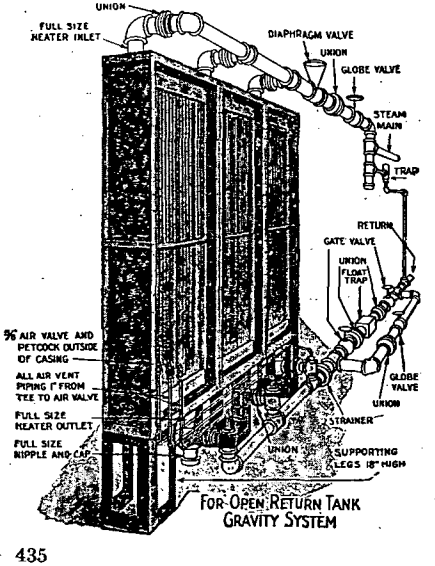
AEROFIN can be erected in the same number of HOURS as would be required in DAYS to erect the heavy heaters.

Figuring Capacities

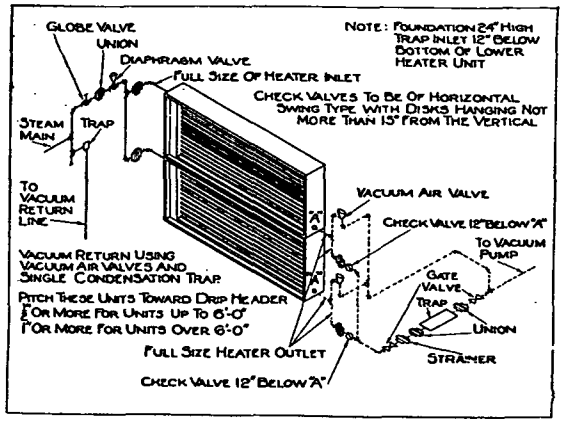
The performance tables and physical data tables cannot be published here on account of the great amount of space required, but these data are contained in our catalogue which will be gladly sent on request.

In our catalogue it will be noted that *face* velocities and net *face* areas are published instead of the usual free area velocities and the corresponding free areas. In case of AEROFIN the net *face* area is just double the *free* area and the face velocity is correspondingly ½ the free area velocity. The net *face* area of any unit equals the tube length times 2 ft., which is the width across the tubes between the inner surfaces of the casing. Hence to

For Diaphragm Valve Control see Chapter on Temperature Regulation in AEROFIN Catalog



For Diaphragm Valve Control see Chapter on Temperature Regulation in AEROFIN *Catalog*



find the net *face* area, simply multiply the tube length by 2 ft.

The single row units have 18 tubes wide, two-row units 35 tubes (18 and 17), and the three-row units 53 tubes (18, 17 and 18). The two-row and three-row units have *staggered* rows of tubes.

Specifications

When ordering AEROFIN, specify number of units, number of rows of tubes in each unit, length of tubes, and assembly, i.e., whether units will be installed with tubes vertical or horizontal, or laid flat, number of sections wide or high. Specify whether steam or water is to be used and what will be the initial pressure. Specify number of steel supporting legs desired. If you also specify C. F. M., temperature range and steam pressure or water temperature, we will check your selection, which is double protection.

If AEROFIN Units are to be laid flat or face down with tubes on a plane parallel with the floor, three-inch drip tappings are required and must not be bushed. This must be clearly specified. **All units must be installed with a pitch toward the drip header.**

If AEROFIN Units are to be used with water, all outlet tappings, in all sizes must be same size as inlet tappings, and this must be clearly specified.

Installation Features—Foundations

It is very necessary with AEROFIN to have foundations sufficiently high to allow the water of condensation to run quickly out of the units and into drip lines or traps. AEROFIN foundations should be from 18 to 24 in. high.

A foundation 24 in. high will be required in cases where a single large float trap handles all the condensation from an entire battery of AEROFIN Units. This trap itself will probably be from 6 in. to 14 in. high with the inlet near the top of the trap—and this trap inlet should be 10 to 12 in. below the bottom of the lower AEROFIN Unit.

A foundation 18 in. high will be sufficient in cases where an individual thermostatic trap is installed on each unit but these traps can be used only on units with tubes 4 feet long and less. A foundation 18 in. high is adequate where gravity return connections are taken out of these units and run down a considerable distance into a receiver. This will allow the condensation to drop out of each unit at least 10 in. before passing through traps, check valves or horizontal gravity return drip pipes. It is very important to have about 10 in. drop out of the units for the condensation so as to free the units of water quickly.

Traps

We recommend the use of one heavy duty float trap for taking care of several AEROFIN Units in a battery. This arrangement is less subject to errors of installation. The use of an individual thermostatic return line trap for each AEROFIN Unit is satisfactory when the installation is made in accordance with our instructions **and may be used on units with tubes 4 feet long and less.** This arrangement, however, is not allowed on the larger sizes of AEROFIN Units because, in many cases, a single unit might require two thermostatic return line traps, and the piping connections would be too complicated and expensive. Generally speaking, we would recommend, therefore, individual return line thermostatic traps for the small sizes of AEROFIN Units and the heavy duty float traps for large sizes and batteries of AEROFIN Units.

Great care should be observed in selecting the proper sizes of traps for AEROFIN Units. Sizes should be figured on the basis of the volume of air being handled, velocities through the AEROFIN, entering air temperature and steam pressure. The rate of condensation in pounds per linear foot per hour can then be looked up in the tables in catalogue, and this figure multiplied by the number of linear feet in each unit gives the total pounds of condensate which must be handled by the trap, and this amount, at the steam pressure being used, determines the trap size.

Check Valves

When one large trap is used to handle the condensation from two or more units, horizontal swing check valves, with disks hanging not more than 15 deg. from the vertical, must be installed on the horizontal drip pipe taken out of the water leg, at least 10 in. below the bottom of the lower AEROFIN Unit.

In cases where an individual trap can be installed on each unit, no check valves are necessary.

Avoidance of Installation Errors

The Installation of AEROFIN with Vertical Tubes is recommended for the reason that this arrangement is less subject to errors of installation and operation. The Horizontal Tube arrangement is entirely satisfactory, however, when installed in accordance with our instructions and diagrams. Either Vertical or Horizontal Tubes may be used with either Gravity Return System or Vacuum Return Line System.

AEROFIN Units set up with tubes vertical, are less subject to installation errors than units set with tubes horizontal, due to the fact that the condensate can remain longer in the bottom header chamber without causing trouble. Installations of AEROFIN with horizontal tubes, with the units set upright, have given perfect satisfaction, but in this case the engineer and contractor must specify and install the units with at least level tubes and preferably with a slight pitch of the units toward the drip tapping. If such a pitch is used the supply end should be set up ½ in. higher than the return end for all units up to 6 ft. in length, and 1 in. higher for all units from 7 ft. to 12 ft. in length. Furthermore, all of the diagrams in the catalogue and on the printed slip pasted on the return end of each unit, indicate a positive recommendation that full size drip nipple be taken out of each unit into a tee or ell and a full size water leg taken out of the bottom of this tee or ell. This is to allow the condensate to flow quickly out of the unit. **The trap connection or gravity return connection (10 in. below bottom of lower AEROFIN Unit) should then be taken horizontally out of the side of this water leg. Installations have caused trouble where the drip tapping has been bushed or reduced and where traps have been installed on a direct line out of the drip tapping from the unit, and such arrangements are absolute contrary to instructions contained in our catalogue.**

AEROFIN Used as a Tempering Coil

Special attention is directed to AEROFIN used as a tempering coil. When an air washer is not used and there is sufficient height for a by-pass underneath the units, the installation may be made according to Fig. 19, Page 34 of the catalogue where a louvre damper is installed covering the entire face of the AEROFIN heater and connected up directly with the by-pass damper, both being operated by a single diaphragm motor controlled by a thermostat located in the discharge duct from the fan. In this case the steam supply valve to the AEROFIN Heater is hand operated.

For other installations, with or without an air washer, the outside battery of AEROFIN should be a single-row unit receiving the freezing air, with hand control or else with control by a thermostat located in the fresh air chamber, and arranged to turn steam on this single-row battery at 35 to 40 deg. above zero and to keep steam on this outside single-row battery at all times when the outside temperature is colder than 35 or 40 deg. above zero. The additional coils required may be arranged as shown in Figs. 20 to 28 in the catalogue.

SPECIAL WARNING is given against the installing of AEROFIN with a 2-row or 3-row battery with duct-thermostat control, to receive freezing air. The off and on control in this case, regulated from the duct thermostat, would probably result in freezing the condensate within the AEROFIN Units and this method of installation is obviously incorrect.

Write for our pamphlet showing special arrangement of two-row AEROFIN Tempering Coils with relay steam control.

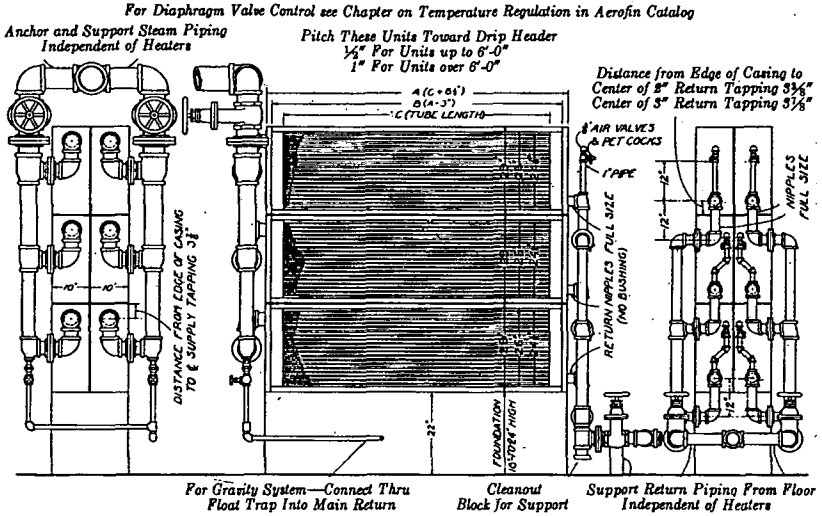
If engineers and contractors will carefully observe instructions and diagrams contained and shown in our catalogue, the operation of AEROFIN will be found eminently satisfactory in all cases.

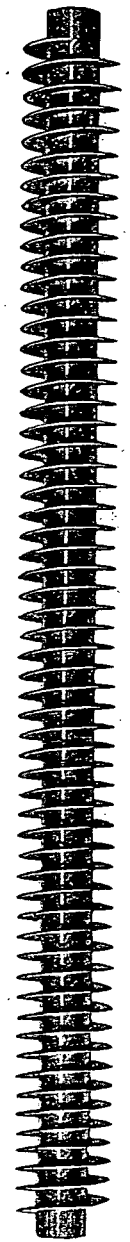
Write for catalogue, instruction leaflet and service details.

Sales

AEROFIN is sold only by Manufacturers of Nationally Advertised Blower Heating Apparatus.

For Diaphragm Valve Control see Chapter on Temperature Regulation in Aerofin Catalog





The Rome-Turney Radiator Co.

Rome, N. Y.

Exclusive Manufacturers of
HELICAL FIN
High Efficiency Extended Surface Copper Radiation
Radiators, Heaters, Condensers, Coolers, Etc.

Products

Standard Heater Units complete with steel casings for fan type heating and ventilating systems, ready for installation.

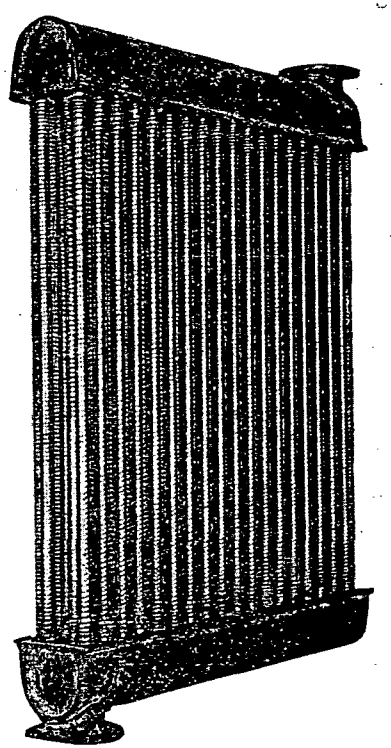
Standard and Special Heater Cores without Casings for manufacturers of Heating and Ventilating Apparatus.

Standard Copper Radiators for concealed direct radiation.

Condensers for Electric Refrigerators.

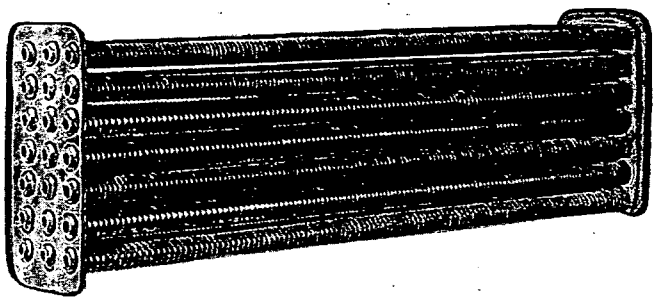
HELICAL Finned Seamless Copper Tubes in all sizes from $\frac{5}{16}$" O.D. to 1¼" O.D. for any type Heat Transfer Equipment.

Cooling Systems and Radiators for Diesel Electric Locomotives, Gasoline Engines, Heavy Duty Trucks and Aeroplanes.



Construction

HELICAL Fin Products are made of heavy gauge Seamless Copper Tubes which are encircled with a continuous flat copper radiating fin, free of corrugations, which is formed under power around the tubes so tightly that there is a copper to copper contact. This fin is attached to the tube by a thorough coating of solder. The tubes are joined to brass header plates by improved methods which insure an absolutely tight union. The headers or tanks are made of a special quality of brass suitable for this type of work.

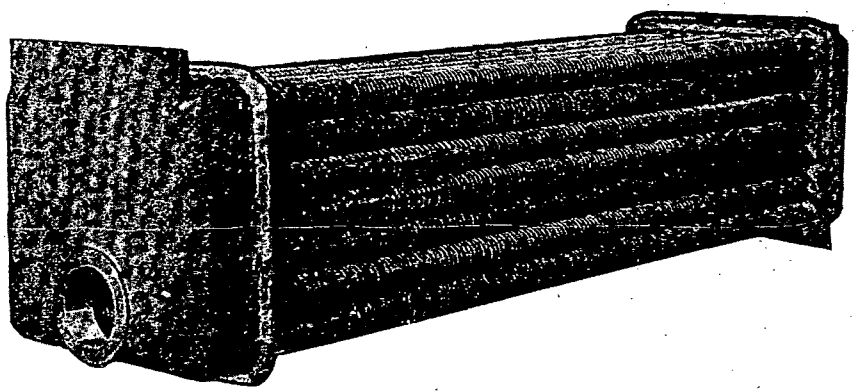


Small size Rome HELICAL Fin Copper Heater suitable for concealed radiation. This shows heater with headers or end tanks removed. Note that tubes are "rolled in" to the tube sheet. Radiators and heaters of this type are suitable for direct radiation.

Advantages

HELICAL Fin Heater Units and Radiators offer great advantages in high efficiency, light weight extended surface radiation. The cores consisting of tubes and headers, are made of copper and brass and are therefore not subject to corrosion.

Data and further information furnished promptly upon request.



Rome HELICAL Fin Copper Heater with headers attached for use either with fan or for direct radiation. Note the sturdy all copper construction. Rome HELICAL Fin Copper Radiation offers sturdy, compact, light weight, highly efficient equipment for any heating installation.

For modern heating equipment in schools, factories, and homes
Specify Rome HELICAL Fin Copper Radiation

Specify
ROME-TURNEY COPPER RADIATION
No corrosion - - - - Good forever

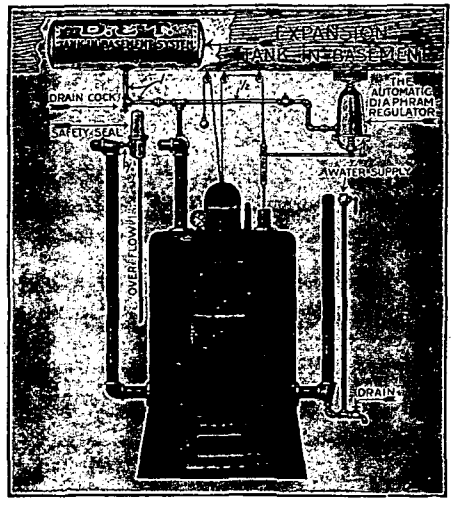
ROME-TURNEY
ROME, N. Y.

Radiator Specialists
since 1905

D. & T. Manufacturing Company

3001 La Salle Street
St. Louis, Mo.

ORIGINAL TANK IN BASEMENT SYSTEM



Placing the expansion tank in the basement on hot water installations is destined to become the one general method. WHY NOT GET INTO THE GAME?

Eleven years' experience and upwards of 100,000 D. & T. Tank-in-the-Basement Systems in successful operation throughout the United States and Canada, should be sufficient proof of the success of this system to the most skeptical heating engineer or contractor.

The D. & T. System is efficient, simple and foolproof.

Send for booklet entitled, "Progress in Hot Water Heating."

As a logical sequence to the development of the tank-in-basement idea, came the growing demand for a specialization of this tested and proved idea—for a basement expansion tank to be used in buildings where extreme simplicity and economy are of paramount importance. To supply this need, we offer and guarantee the Simplex Air-Sealed Tank-in-Basement Equipment.

The Simplex Air-Sealed Tank-in-Basement Package Equipment consists of:

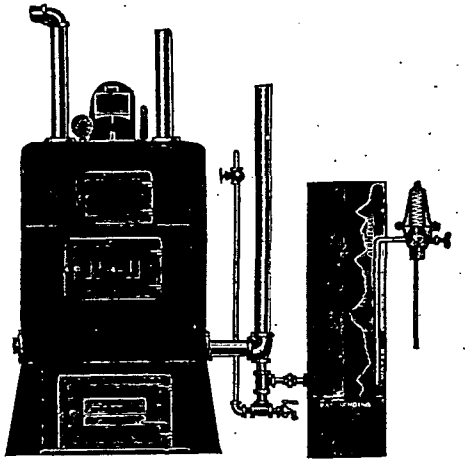
1 Specially Constructed Airtight Expansion Tank

1 Relief Valve

1 Thermometer

1 Gauge

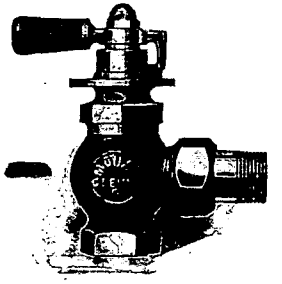
1 Vacuum Breaking Valve for automatically charging Tank with air.

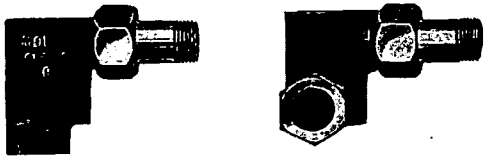


The Mouat Vapor Heating Co.

1246 W. Fourth Street .·. CLEVELAND, OHIO

The Mouat System of heating is 2-pipe gravity vapor, operating at from 1 to 3 oz. pressure, resulting in positive and successful hand control of the supply of heat at the radiators. It has no pumps, return traps or mechanically operated parts.





RADIATOR RETURN FITTINGS

The Mouat Radiator Return Fitting is a specially designed water seal, with a by-pass for air. It also has provision for drainage to prevent freezing.

NOTE—All of the Mouat Specialties have been designed to work in conjunction with one another; therefore, these specialties are not sold separately, but only complete for each installation.

Our organization is composed of a trained corps of specialists in Mouat Vapor Heat. They have had many years of practical experience and have designed and supervised thousands of installations. These specialists are at your service.

PACKLESS FRACTIONAL RADIATOR SUPPLY VALVES

Has Jenkins Disc and is substantially made. Easily adjusted, when installed, to suit the size or working conditions of the radiator to which it is connected.



AIR RELIEF VALVES

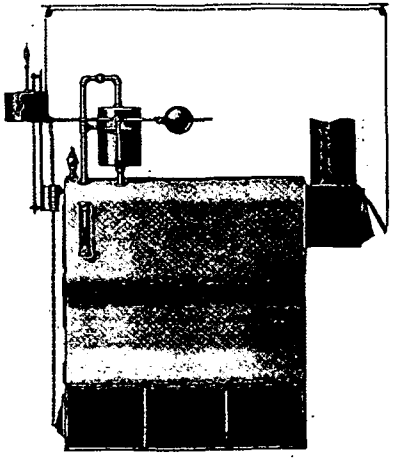
The Mouat Air Relief Valve or Main Vent is provided with a properly proportioned venting area.

It has no thermostatic, mechanically operated or float parts.



VAPOR PRESSURE GAUGES

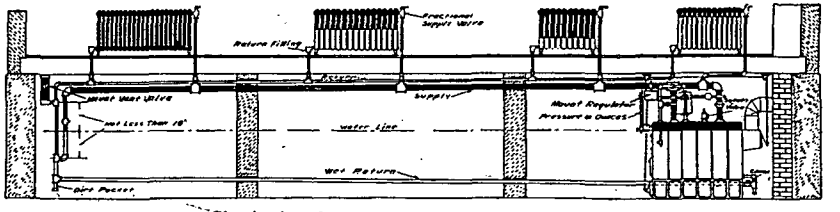
The Mouat Vapor Pressure Gauge indicates ounces of pressure by water elevation in a glass tube.



DAMPER REGULATORS

This regulator is controlled by the pressure in the boiler and automatically regulates the drafts. It will maintain a pressure of from one to three ounces, and is sufficiently sensitive to operate at a variation of less than one ounce. The working parts are connected above the water line of the boiler and are not affected by a high or low water line or the variations of an unsteady water line. No water can be forced out of the boiler through the regulator.

This regulator can also be used to reduce steam pressure to vapor pressure on central station heating plants.



Showing how the Heat can be Graduated or Controlled

MUELLER CO.

Decatur, Ill.

BRANCHES

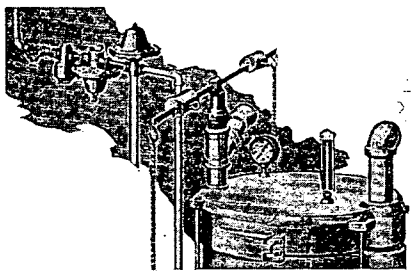
E. 135th St. and Walnut Ave., Bronx, New York 1072-76 Howard St., San Francisco 2468 Hunter St., Los Angeles

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.

When air is released from a radiator it is not necessary to go to the basement to turn water into the system as is the case with other systems. The reducing valve takes care of this.

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.

Reducing and Regulating Valves—For steam, water, air, gas, oil, etc., and relief valves that are absolutely dependable. They will not stick after long periods of disuse.

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.

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

Branch Offices

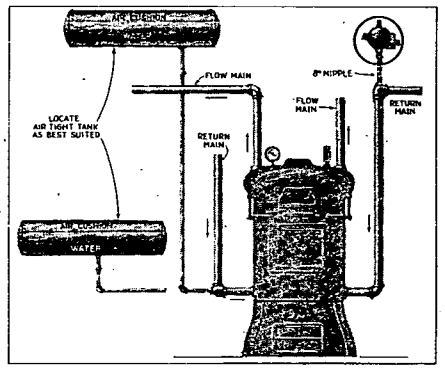
ATLANTA, GA.	525 Virginia Avenue	DENVER, COLO.	1700 Fifteenth Street
BOSTON, MASS.	141 Milk Street	LOS ANGELES, CAL.	701 East Third Street
CHICAGO, ILL.	130 North Jefferson Street	SAN FRANCISCO, CAL.	320 Market Street
ST. LOUIS, MO.	1912 Pine Street	PORTLAND, ORE.	474 Glisan Street

NEPTUNE METER CO., LIMITED, 345 Sorauren Avenue, Toronto, Ontario

RED TOP
PRESSURE SYSTEM
OF HOT WATER HEATING

This type of heating system is proving increasingly popular throughout the country. It is easily installed at a price which attracts the owner, builds good will for the architect and engineer while allowing a real profit for the contractor.

Owners appreciate the high efficiency and the economy effected by the **Red Top Pressure System.**

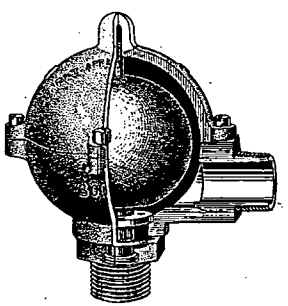


RED TOP RELIEF VALVE
MODEL No. 2

This valve and an airtight expansion tank, to be located in the basement near the apparatus, are the only special pieces of equipment needed.

Red Top Relief Valves act on the dead weight or gravity principle, and are the only valves of their kind to be approved by the Underwriters' Laboratories, Inc.

In the **Model No. 2** a special nickel weighted piston is forced off the seat when pressure reaches 30 pounds. Non-corrosive metal is used throughout, and there are no springs, levers or other complicated parts to get out of order. Made for either "open" or "closed" systems. They are 6½ inches high, 5¾ inches wide, with inlet threaded for standard 1 inch fitting and male outlet threaded for 1 inch fitting.



Sectional View, Red Top Relief Valve Model No. 2

RED TOP MODEL No. 1 protects domestic hot water supply, and prevents range boiler explosions and other ruptures. It is made with inlet threaded for standard ½ inch pipe fitting and outlet drilled and tapped for ½ inch connection. It may be adjusted to relieve automatically at 50, 75, 100 and 130 lbs. pressure. Its measurements are 4½ inches high and 4 inches wide.

Reading Heater & Supply Co.

Incorporated

GENERAL OFFICES

Woodward and Church Streets

Reading, Pa.

Manufacturers and Distributors of

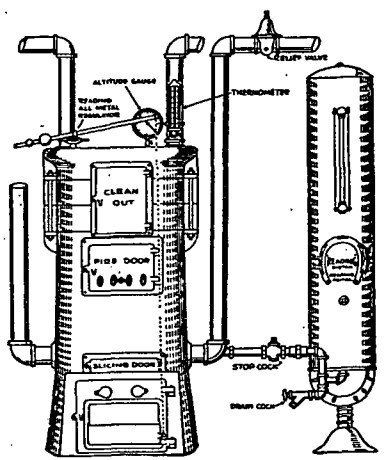
The Reading Tank-in-the-Basement Systems for Hot Water Heating and The Reading All-Metal Temperature Regulator for Hot Water Heaters, Domestic Heaters and Storage Tanks, Wholesale Dealers in Boilers, Radiators and Heating Specialties.



The Reading Tank-in-the-Basement System, for Hot Water Heating, is a long step in advance of the old method of placing the Expansion Tank above the highest radiator, in that it removes the tank to the basement, obviating many objectionable features and removing the liability of fracture by freezing of the expansion line or overflow.

The Reading Tank is proportioned according to the amount of radiating surface on the job, and provides ample air space to allow for expansion. The gauge glass enables the operator to detect any air leakage and to maintain a sufficient air space.

The Reading Relief Valve permits a slight pressure on the system, even when the water is cold. This means increased efficiency and prevents the accumulation of air in the upper radiators. The increased pressure will not cause leaks as the air cushion prevents undue strains. We furnish complete instructions for installation.



Capacities and Prices

(Subject to trade discount)

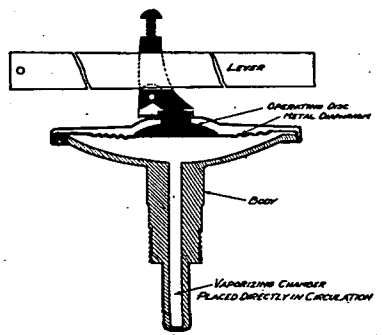
No. 1.	300 to	500 ft. of Radiation	$38
No. 2.	500 to	800 ft. of Radiation	40
No. 3.	800 to	1,000 ft. of Radiation	41
No. 4.	1,000 to	1,300 ft. of Radiation	45
No. 5.	1,300 to	1,800 ft. of Radiation	50
No. 6.	1,800 to	2,600 ft. of Radiation	56

In ordering Reading Tank-in-the-Basement Systems the following information is required: Amount of radiation on job, square feet; number of stories to be heated.

The Reading All-Metal Regulator can be used to control water temperature in any system, regardless of pressure carried. The Regulator is easily applied and the action is sensitive and reliable.

We will be glad to send a catalog describing our complete line of Specialties, upon request. Our Engineering Department will welcome the opportunity to assist the trade in difficult problems pertaining to our line, and we invite such inquiries.

We carry a large stock of boilers of all capacities, Round or Sectional, and can make prompt shipments.



INTERIOR VIEW
READING ALL METAL TEMPERATURE REGULATOR

Grinnell Company, Inc.

Heating, Industrial and Power Plant Piping, Fittings, Hangers, Valves, Pipe Bending, Welding, Piping Supplies, Etc.

Executive Offices

PROVIDENCE, R. I.

BRANCHES AND PLANTS

Albany, N. Y.	Columbus, Ohio	Minneapolis, Minn. (Plant)
Atlanta, Ga. (Plant and Foundry)	Dallas, Texas	New Orleans, La.
Auburn, R. I. (Plant and Foundry)	Denver, Colo.	New York, N. Y.
Baltimore, Md.	Des Moines, Iowa	North Charlotte, N. C. (Plant)
Boston, Mass.	Detroit, Mich.	Orlando, Fla.
Buffalo, N. Y.	Hartford, Conn.	Philadelphia, Penna. (Plant)
Charlotte, N. C.	Indianapolis, Ind.	Providence, R. I. (Plant and Foundry)
Chicago, Ill. (Plant)	Kansas City, Mo.	Rochester, N. Y.
Cincinnati, Ohio	Kearny, N. J. (Plant)	St. Louis, Mo.
Cleveland, Ohio	Milwaukee, Wis.	Warren, Ohio (Plant and Foundry)

GRINNELL COMPANY OF THE PACIFIC

Los Angeles, Cal. (Plant) San Francisco, Cal. (Plant) Seattle, Wash.

GRINNELL COMPANY OF CANADA, LTD.

Montreal, Que. (Plant) Toronto, Ont. (Plant and Foundry)
Vancouver, B. C. (Plant) Winnipeg, Man.

Cooperative Engineering and Contracting Service on Heating Systems—Seventy years' experience in piping installation puts Grinnell Company, Inc., in an especially advantageous position to render service of the highest order to heating engineers and their clients. This not only includes a cooperative advisory service which is frequently used by engineers who desire authoritative practical information when working on problems more or less out of the ordinary, but also a complete and expert contracting service as well.

Close contact with power and industrial piping enables Grinnell Engineers to approach questions of heating with full realization of their relationship to other factors. Information supplied by members of the Grinnell Staff regarding the utilization of waste heat through the agency of hot water systems, the utilization of exhaust steam, etc., has proved of invaluable assistance in working out more efficient heating.

Grinnell Engineering or Contracting Service is equally satisfactory on the remodeling of old heating systems—a type of work with which the Company is thoroughly familiar.

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 installations of this type of heating system.

This whole complication 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 perfect equalization of flow to every radiator than has ever been 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 of 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. It is so designed that after the installation is completed a multiple-orifice cartridge or tube, having a definite resistance pre-determined by Grinnell Co., is dropped into place in same.

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.

Power and Industrial Piping—The advantages of placing contracts for all necessary piping with one reputable company are obvious. Responsibility is centralized and a saving in cost is often effected. Grinnell Company, Inc. is prepared to submit bids and render expert, personally supervised construction service on all types of Power Plant and Industrial Piping including Automatic Sprinkler Systems, piping for Acids, Alkalis, etc., Compressed Air Cleaning Systems, Humidifying Systems, Drying Machinery. A contract placed with Grinnell Company is carried out to the satisfaction of all concerned. Materials of the highest quality are used. Grinnell Adjustable Hangers and Grinnell Fittings, for instance, save work in installation and make for cleaner, more satisfactory finished jobs and lower maintenance costs.

Pipe Bends, Welds, Etc.—Grinnell facilities for making Pipe Bends, Welds and Lap Joints are second to none. Three plants—Providence, R. I., Auburn, O., Atlanta, Ga.,—equipped with special modern machinery and operated by the most skillful 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.

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 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 two following pages are shown a few Grinnell Hangers of particular interest to heating engineers. The Grinnell Hanger Blue Book, however, illustrates and describes the complete line and carries mechanical drawings and dimensional tables on practically every hanger shown. This feature alone makes the Grinnell Hanger Blue Book invaluable to Engineers, Architects and Draftsmen. As many copies as you require will be sent on request.

Adjustable Swivel Ring—Solid Ring Type

(Patented October 4, 1921)



Fig. No. 101

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.

The unusual feature of this ring is the Swivel Shank. An adjustment of at least 1½ in. is secured by simply turning the nut on the shank. No temporary support of the pipe line is necessary while making adjustments.

By means of a unique locking device the Swivel Shank automatically locks, preventing loosening due to vibration in the pipe line.

Adjustable Swivel Ring—Split Ring Type

(Patented October 4, 1921)



Fig. No. 104

THE Split Ring Type of the Adjustable Swivel Ring was also designed for use with Coach Screw Rod or with Machine Threaded Rod. The Swivel Shank feature allows the same adjustment as in Fig. No. 101 and the off-center hinging of the ring, by providing sufficient seating to hold pipe securely, permits adjustments before the Ring is closed. The closing of the hinged section of this Ring securely locks the Swivel Shank.

Universal Side I-Beam Clamp

(Patented April 6, 1915)

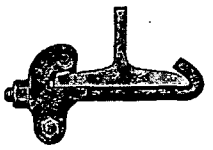


Fig. No. 225

ADAPTABLE to many uses, this Side I-Beam Clamp has ample strength for hanging ¾ to 12 in. pipe from I-Beams. This Clamp in different sizes will fit all sizes of Standard and Bethlehem I-Beams, and most sizes of Bethlehem Girder Beams.

Under conditions requiring vertical adjustment of the pipe line, this Side I-Beam Clamp is used with an Extension Piece or an Extension Eye Bolt.

Universal Channel Iron Clamp

(Patented April 6, 1915)

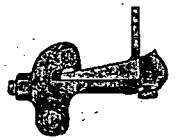


Fig. No. 226

DUE to the adjustability of the Grinnell Channell Iron Clamp, three sizes of these clamps, with varying lengths of clamp rods, will meet most of the conditions encountered in practical installation work in connection with channels. We know of nothing else on the market which will obviate the necessity for the making of specials for Channel Iron work.

GRINNELL COMPANY

Heating, Industrial and Power Plant Piping, Fittings, Hangers, Valves, Pipe Bending, Welding, Piping Supplies, Etc.

Adjustable Wall and Column Radiator Brackets

(Patents Pending)

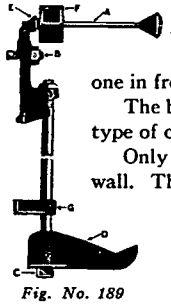


Fig. No. 189

THE bracket on the right, 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.

The bracket on the left, Fig. 189, is designed to support the legless type of 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. Cost of installation can be further reduced by spacing these hangers farther apart than ordinary type of weaker construction, especially where hook bolts are set in the wall.

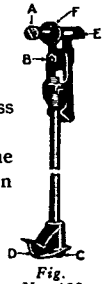


Fig. No. 190

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.

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.

Besides the adjustable advantages of these hangers which permit the hanger plate to be raised or lowered to secure perfect pipe alignment, it is only necessary to fasten the individual bracket in place by two bolts. This saves labor.

Saddle Hangers—Standard Type

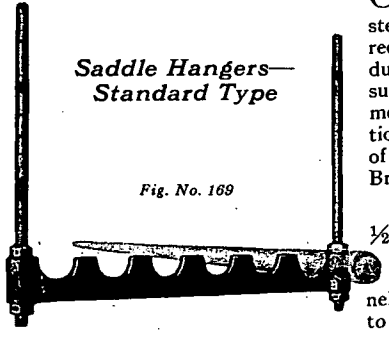


Fig. No. 169

GRINNELL Saddle Hangers are unique inasmuch as the hanger bar is of steel instead of cast iron. This feature not only reduces the weight of the hanger but also reduces its cost. Hex-nuts at bottom of rods support the hanger and allow liberal adjustment. These Saddle Hangers are exceptionally strong and will not sag. Labor cost of installation is considerably less than with Branch Rolls and Rods.

The Saddle Hanger is used in connection with ½ in. rods and hex-nuts on 2 to 8 branch hangers —⅝ in. rods and hex-nuts on 9 to 12 branch hangers—and with Expansion Cases, Grinnell Hanger Flanges, or with Side I-Beam Clamps to steel work, for supporting overhead coils.

GRINNELL COMPANY

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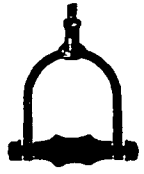


Fig. No. 174

Adjustable Swivel Pipe Roll

(Patented October 4, 1921)

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.

Branch Pipe Rolls

GRINNELL Pipe Rolls are especially designed to take care of expansion and contraction. The rolls are made hollow so that only a small surface is in contact with the rod whereas the surface in contact with the pipe is made as large as possible. This allows the roll to take care of expansion and contraction properly.

Through a specially designed socket, vertical adjustment is allowed at the bottom of each vertical rod as well as at the Ceiling Flange. Furthermore, the nut at the bottom of the hanger rod fits into a recess of the socket preventing loosening or turning from vibration.

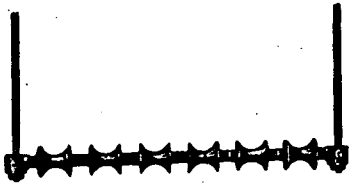


Fig. No. 172

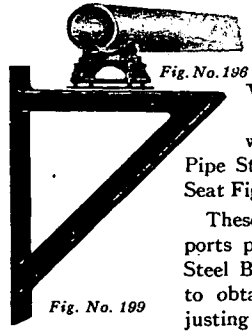


Fig. No. 196

Fig. No. 199

Adjustable Pipe Stand—Anchor Chair—Pipe Seat—used with Welded Steel Bracket

WELDED Steel Bracket Fig. No. 199 is light in weight as compared with the usual cast iron brackets. It was designed primarily for use with the Grinnell Adjustable Pipe Stand Fig. No. 196, Anchor Chair Fig. No. 197 and Pipe Seat Fig. No. 198, here illustrated.

These combine the strongest type of brackets and pipe supports procurable. The Adjustable Pipe Stand as used with the Steel Bracket has excellent adjustment features, it being possible to obtain vertical adjustment by simply adjusting bolts on the roll stand. A lateral adjustment or movement is possible with the Adjustable Pipe Stand and Pipe Seat by sliding the Stand or Seat on the bracket. With the Anchor Chair, lateral adjustment is also possible if Chair is moved before the nuts on the anchor yoke are tightened.



Fig. No. 197



Fig. No. 198

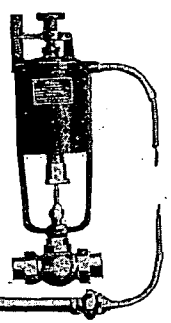
American Schaeffer & Budenberg Corp.

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Manufacturers of Indicating and Recording Gauges; Draft Gauges; Indicating and Recording Thermometers; Tachometers; Pressure and Temperature Controllers; Pop Safety and Water Relief Valves; Gauge Testers; "U" Gauges; Steam Traps; Engine Indicators; Counters; Calorimeters; Locomotive and Engine Room Clocks; Barometers; Steam Whistles; Hydraulagraphs; Gauge Boards

American Temperature Controller



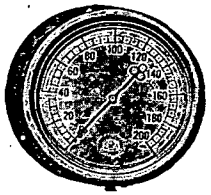
American (formerly Honeco) self-operated Temperature Controller, type 2205, is exceptionally well adapted for maintaining any desired temperature of the water in hot water tanks.

It has a wide range and close control at the setting point, giving a 50 per cent safety factor even at the maximum point of range without damage. Adjusting device locks the controller against unauthorized interference.

No expensive pipe lines, compressed air or auxiliary force is required for operation. The motive power needed to open and close valve is supplied by the controller itself. The patented motor is unusually strong and durable and the instrument itself is extremely rugged throughout.

The American Controller is guaranteed to accurately perform its function for the purpose sold when properly installed.

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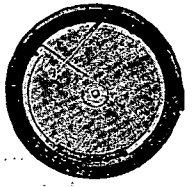
American Indicating Gauges

A complete line of American pressure, vacuum and draft gauges for all purposes.

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American Recording Gauges and Thermometers

The recording systems of American (formerly Columbia) Recording Gauges and Thermometers are interchangeable. A separate recording system can be kept in stock at small cost and quickly inserted while the old one is being repaired, should repairs be necessary due to accident.



Instructions are lithographed on the chart plate, so they can not be lost. Time punch shows when and how often readings are taken. Any slight inaccuracies due to rough handling can be quickly corrected by means of the adjusting device. The chart is held in place by a non-removable clamp, preventing loss of clamp. Automatic pen release lifts pen arm away from chart automatically when the door is opened, preventing arm from being strained. Fitted with an inverted Monel metal pen arm with tension adjusting device and non-corrosive glass pen. Has 10-in. chart with extra large recording area.

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Built on extremely rugged lines and guaranteed for all pressures. Valve discharge orifice is much larger than in ordinary traps, which means larger capacity. Valve seat can be renewed without disconnecting trap. The heavy float is made of seamless, non-corroding copper. It resists pressures up to 600 lbs. per sq. in. and is guaranteed for life of trap. Valve seat is under continuous water seal, thus cannot leak live steam.

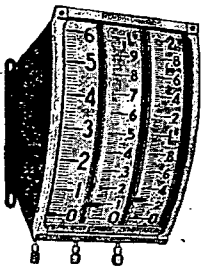
Send for Catalog S-59.

Draft Gages
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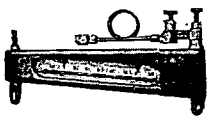
The Hays Corpn.

Michigan City, Indiana

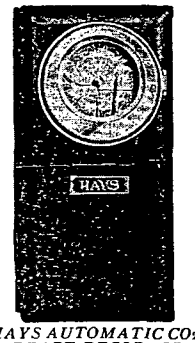
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Portable Test Sets



TYPE V 3 1 TO 12" SCALES



HAYS INCLINED TUBE DRAFT GAGE—Rugged, Accurate, Inexpensive



HAYS AUTOMATIC CO_2 & DRAFT RECORDER—The simplified and Improved Model "B"

Hays Combustion Instruments

Save Fuel
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Draft Gages are undoubtedly the most important all-'round useful instrument in combustion, heating and ventilation. They indicate conditions of fuel bed, baffles, gas passages, ducts, flues and settings and suggest the cause and remedy. No other one instrument covers so many uses, or is so indispensable. We offer a complete line for every purpose.

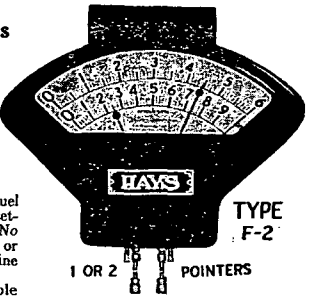
Hays Pointer Gages are available in two kinds of cases, Type "F" for one or two pointers and Type "V" for any number of scales grouped in a side-by-side arrangement. These gages are new in principle and design and do not employ liquids, floats, tanks, gears or magnets. The simple operating mechanism consists of a slack leather diaphragm—a pliable, tough, gas-tight animal membrane—and a phosphor bronze cantilever spring. Any range can be supplied. Leveling is unnecessary. Calibration is permanent.

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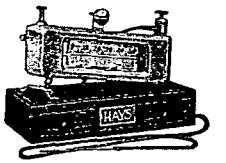
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Hays Automatic CO_2 and Draft Recorder shows "what", "why," and "when" about the way fuel is burned. Easy to install and operate. Dependable, rugged and simple. Great dividend payers.

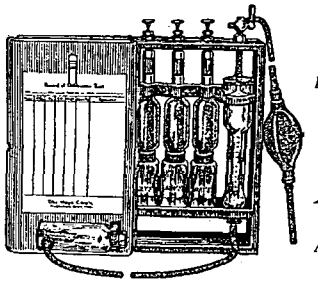
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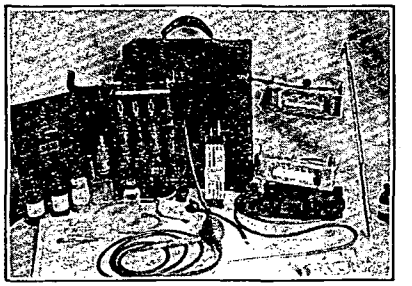


Portable Draft Gage—This inclined tube gage comes in a pocket case. Removable supporting foot, permits setting the gage up on any flat surface. A knurled wall screw and rubber tubing are also furnished. Ideal for testing chimney draft, locating trouble, reducing service expense. Write for treatise on use of Draft Gage by Prof. A. P. Kratz, University of Illinois.



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Designed for Air Ducts are extremely sensitive and are used extensively by heating and ventilating engineers.

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Used to record air duct temperatures. The self-contained type (not illustrated) is used to record room temperatures—Clock furnished with 7 day charts.

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A convenient method of obtaining relative humidity records. Equipped with blowers to keep air moving over bulbs at uniform velocities.

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Type P is supplied with flange connections for air ducts, air washers, and room conditioners, etc.

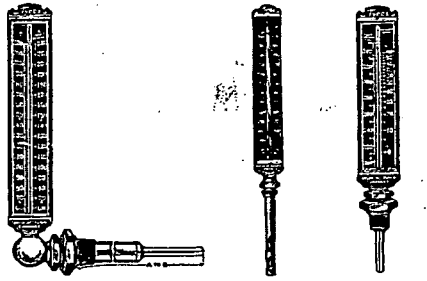
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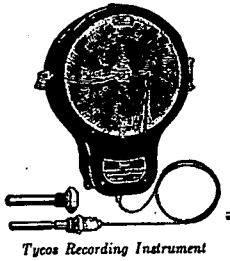
For registering velocity of air currents.

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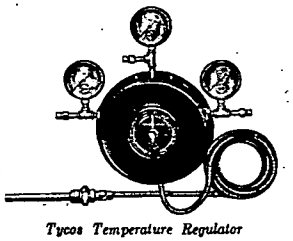
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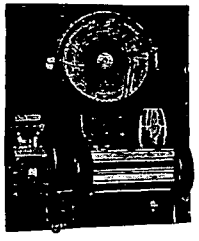
Tycos Thermometers



Tycos Recording Instrument



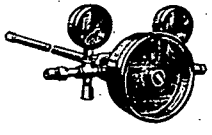
Tycos Temperature Regulator



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Tycos Type P Temperature Regulator

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UNDERGROUND CONDUIT SYSTEMS FOR HEATING PIPES

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Products—RIC-WIL Interlocking Conduit, Interlocking Base Drain, Pipe Supports and RIC-WIL Underground Pipe Covering used in the "RIC-WIL Method" of Insulating Underground Steam, Hot Water and Fuel Oil Pipes.

Ric-wiL Interlocking Conduit—RIC-WIL Conduit is first quality, standard weight, vitrified salt glazed tile of the bell and spigot type. It is shipped on the job in full round sections and split into top and bottom halves as used. When installed bell and special Loc-liP side joints are sealed with Portland cement. Loc-liP joint (see illustration below) is shaped so that cement locks top and bottom halves permanently together in all directions, giving conduit extraordinary rigidity and strength. Leakage is practically impossible. Top and bottom halves are interchangeable (foolproof) and numbered in pairs so that companion pieces may be kept together.

Sections all in 2-ft. lengths, sizes from 4 to 24 in. inside diameter. Every sixth section of conduit has an opening in the bottom half through which a pipe support of the roller type projects to carry the steam, hot water or oil pipes thus making the pipe supports independent of the conduit itself, a desirable feature for this class of work.

Ric-wiL Interlocking Base Drain—RIC-WIL Base Drain is first quality vitrified salt glazed tile of such design that it is both a base for supporting and lining up the conduit, and drain for carrying away any water which might otherwise accumulate around the conduit. The base drain also provides two points of support for conduit, adding 35 per cent to the ground load which the conduit will carry safely as compared to the same conduit placed on flat ground or broken stone. The top of the base drain has a slot in it into which the bell of conduit fits making sections of conduit and base drain stagger with each other so that a strong interlocking construction results. No concrete foundation is necessary in solid ground. Free drainage area of the base drain is large and ample for every practical condition. Three sizes are made: No. 1 for 4 and 6 in. conduits, No. 2 for 8 to 15 in. conduit, inclusive, and No. 3 for larger sizes. We will furnish ordinary drain tile instead of base drain if desired but the base drain will save more than its extra cost in labor and makes a far better job.

Ric-wiL Pipe Supports—The pipe supports are planned to carry from one to five or more pipes and are ordinarily spaced 12 ft. apart. They are strong, made of cast iron, rust proofed, and interlocked with the base drain, imposing no load on the conduit itself. Once in place, no movement of the pipes can disturb them.

Ric-wiL Conduit Systems for All Uses—RIC-WIL Conduit for underground pipe is of four types to meet varying service requirements.

Type SPC System for steam heating and power pipes and for superheated steam. The tile itself is not lined with insulation as in types *DA* and *DF* but the insulation is applied to pipes direct and consists of any standard make of sectional pipe covering, the kind and thickness depending upon the service to be rendered. Double drainage is provided in this type.

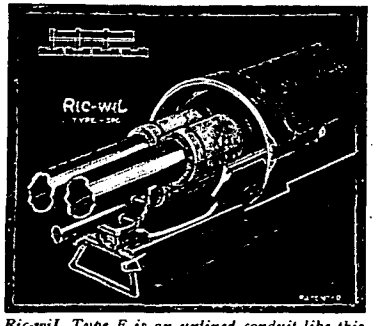
Type F System for steam heating and power pipes. A lower priced type than the others, consisting of unlined RIC-WIL Conduit with filler packed around the pipes. Filler is the same as described in Type *DF* System.

Type DA System for hot water, fuel oil, and condensation returns. Tile and insulation in one, the latter moulded inside the tile and keyed in. Consists of a diatomaceous earth (Sil-O-Cel) mixture, light in weight and of high insulating quality; will not deteriorate. This type insulates the pipes from surrounding ground but not from each other, making it specially adapted to house oil and steam pipes together for fuel oil transmission. Exceptionally easy to install.

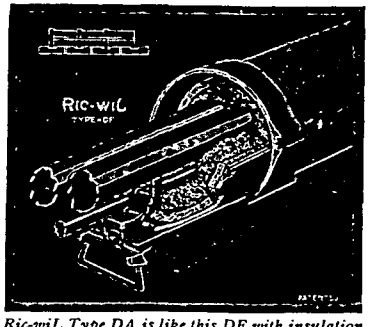
Type DF System for steam heating and power pipes. This is type *DA* with the addition of RIC-WIL Conduit Filler to be packed around the pipes at a density specified by the manufacturer. The filler is a good non-conductor which will not corrode the pipes nor shrink.

Cast Iron Ric-wiL Conduit—*For extra heavy* duty under railroads or other places where conduit is subject to very heavy load, Ric-wiL is made of cast iron similar in design to regular tile Ric-wiL. It has the Loc-liP Joint and the "interlox" with regular conduit. Special reinforced base drain is furnished.

Engineering Service—Maintained for the convenience of customers. Inquiries answered promptly. Catalogs and special information furnished on request.



Ric-wiL Type F is an unlined conduit like this SPC, insulation being a loose filler packed around the pipes.



Ric-wiL Type DA is like this DF with insulation moulded to tile but without loose filler.

The Celotex Company

645 N. MICHIGAN AVENUE, CHICAGO

CELOTEX
INSULATING LUMBER

Mills: NEW ORLEANS

Branches in Many Principal Cities

Data for Computing Heating Requirements of Insulated Homes

Compiled by H. J. BURT, Consulting Structural Engineer, Chicago

THE most direct way for a householder to cut down the cost of his winter's coal supply is to buy and to burn a smaller quantity of it. He can do this without sustaining inconvenience, discomfort or ill health.

The means of accomplishing this result is by the use of insulation.

All materials permit the passage of heat, some a great amount and others very little. Careful tests have been made of the passage of heat through the materials commonly used, so that their values are known.

The merit of Celotex insulating lumber is shown by the following comparisons:

Celotex	0.33
Wood sheathing	1.25
Plaster	1.50
Brickwork	4.00
Concrete	6.00

All of the above values are for one inch thickness.

Expressed in another way, one inch of Celotex is equal to 3¾ inches of wood, 4½ inches of plaster, 12 inches of brick or 18 inches of concrete.

The following table gives some typical values arranged to show the percentage of saving resulting from the use of insulation:

WALL SECTIONS

Construction	Non-Insulated Conductance	Insulated Conductance	Per Cent Saving
Wood siding, building paper, wood sheathing ⅞-in., lath and plaster	0.265	.....	.....
Wood siding, Celotex as sheathing, Celotex as plaster base, plaster	.....	0.182	31
Stucco, building paper, wood sheathing, lath and plaster	0.267	.....	.....
Stucco, Celotex as sheathing, Celotex as plaster base, plaster	.....	0.183	31
Brick veneer 4-in., building paper, wood sheathing, lath and plaster	0.24	.....	.....
Brick veneer 4-in., Celotex as sheathing, Celotex as plaster base, plaster	.....	0.17	29
Brick wall 8-in., furring, lath and plaster	0.24	.....	.....
Brick wall 8-in., furring, 2 layers of Celotex serving as plaster base, plaster	.....	0.143	40

The amount of insulation desirable for a house depends on climatic conditions. For average conditions two layers of Celotex are desirable.

The data on the opposite page are from a report by G. F. Gebhardt, mechanical engineer, Chicago, to H. J. Burt.

We submit herewith results of our estimate on the co-efficiency of heat transmission for walls and ceilings, details of which were submitted by you recently. We also submit tables of heat conductivity co-efficients and surface factors for the various materials entering into the proposed construction. The co-efficients of heat transmission are expressed in B.t.u. transmitted per square foot of surface per hour per degree Fahrenheit difference in temperature between the inside and outside air.

WALL SECTIONS

Number	Construction	Coeff. of Heat Transmission B.t.u. per sq. ft. per hour
1	Wood siding (clapboard or shiplap) on studs. No inside lining	0.57
1a	Celotex ⅝-in. thick on siding. No inside lining	0.42
2	Wood siding. Building paper, wood sheathing ⅞-in. No inside lining	0.41
2a	Wood siding. Celotex sheathing. No inside lining	0.35
3	Wood siding. Building paper. Wood sheathing ⅞-in., lath and plaster	0.265
3a	Wood siding. Celotex sheathing. Lath and plaster	0.24
3b	Wood siding. Celotex sheathing. Celotex plaster on Celotex	0.182
4	Stucco, building paper, wood sheathing, lath and plaster	0.267
4a	Stucco, Celotex sheathing, lath and plaster	0.24
4b	Stucco, Celotex sheathing, Celotex as plaster base, plaster	0.183
5	Brick veneer 4-in., building paper, wood sheathing, lath and plaster	0.24
5a	Brick veneer 4-in., Celotex sheathing, lath and plaster	0.217
5b	Brick veneer 4-in., Celotex sheathing, Celotex as plaster base, plaster	0.17
6	Brick wall 8-in., furring, lath and plaster	0.24
6a	Brick wall 8-in., furring, Celotex, plaster on Celotex base	0.182
7	Brick wall 12-in., furring, lath and plaster	0.193
7a	Brick wall 12-in., furring, Celotex, plaster on Celotex base	0.154
8	Stucco, tile wall 8-in., furring, lath and plaster	0.19
8a	Stucco, tile wall 8-in., furring, Celotex, plaster on Celotex base	0.153
9	Stucco, concrete wall 6-in., furring, lath and plaster	0.267
9a	Stucco, concrete wall 6-in., furring, Celotex, plaster on Celotex base	0.198
10	Stucco, concrete wall 12-in., furring, lath and plaster	0.21
10a	Stucco, concrete wall 12-in., furring, Celotex, plaster on Celotex base	0.165

ROOF SECTIONS

1	Wood shingles on wood strips spaced 2-in. apart	0.667
1a	Wood shingles on wood strips. Celotex sheathing	0.35
2	Wood shingles, wood sheathing ⅞-in.	0.455
2a	Same as No. 1a	0.35
2b	Wood shingles on wood strips, Celotex sheathing, Celotex lining under rafters	0.191
3	Metal shingles on wood strips spaced 2-in. apart	Practically no heat insulation
3a	Metal shingles on wood strips, Celotex sheathing	0.54
3b	Metal shingles on wood strips, Celotex sheathing, Celotex lining under rafters	0.236
4	Metal shingles, wood sheathing, ⅞-in.	0.833
4a	Metal shingles, on wood strips, Celotex sheathing	0.54
4b	Metal shingles on wood strips, Celotex sheathing, Celotex lining under rafters	0.236
5	Slate 1-in., roofing felt, wood sheathing, ⅞-in.	0.444
5a	Slate 1-in., wood strips, Celotex sheathing	0.372
5b	Slate 1-in., wood strips, Celotex sheathing, Celotex lining under rafters	0.197
6	Clay tile ½-in. Roofing felt, wood sheathing	0.496
6a	Clay tile ½-in., wood strips, Celotex sheathing	0.412
6b	Clay tile ½-in., wood strips, Celotex sheathing, Celotex lining under rafters	0.208
7	Asphalt shingles, wood sheathing ⅞-in.	0.553
7a	Asphalt shingles, Celotex sheathing	0.407
7b	Asphalt shingles, Celotex sheathing, 2 layers	0.25
8	Asbestos shingles, wood sheathing ⅞-in.	0.55
8a	Asbestos shingles, wood strips, Celotex sheathing	0.404
9	Composition roof, wood deck 2-in.	0.322
9a	Composition roof, Celotex, wood deck 2-in.	0.22
9b	Same as 9a, except two layers Celotex	0.17
9c	Same as 9a, except three layers Celotex	0.14
10	Composition roof, concrete deck 3-in.	0.65
10a	Composition roof, Celotex, 1 layer, Concrete deck 3-in.	0.35
10b	Same as 10a, except two layers Celotex	0.24
10c	Same as 10a, except three layers Celotex	0.18

CONDUCTIVITY CONSTANTS

Wood siding	1.4	Hollow clay tile	3.2
Celotex	0.33	Concrete	6.0
Wood sheathing	1.25	Wood shingles	1.0
Wood deck, soft pine	1.0	Slate	2.5
Building paper, one thickness	4.2	Tar and felt roofing, 5-ply (as laid, not per inch)	5.0
Wood lath and plaster	1.4	Clay tile	3.5
Plaster	1.5	Asphalt shingles (as laid, not per inch)	6.5
Portland cement stucco	2.0	Asbestos shingles (as laid, not per inch)	6.0
Common brick	4.0	Composition roof (as laid, not per inch)	6.5

SURFACE CONSTANTS

Wood siding	2.1	Concrete	2.3
Celotex	1.9	Wood shingles	2.0
Wood sheathing	2.0	Slate	2.3
Lath and Plaster	2.3	Tar and felt roofing	2.1
Portland cement stucco	2.3	Asphalt shingles	2.2
Common brick	2.3	Asbestos shingles	2.2
Clay tile	2.3		

Johns-Manville Inc.

Miners of Asbestos, Manufacturers of Asbestos and Allied Products

EXECUTIVE OFFICES

292 Madison Avenue, at 41st Street - NEW YORK, N. Y.

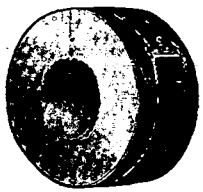
Branches in All Large Cities

DIVISION SALES OFFICES

BOSTON 9, MASS., 55-63 High Street
CHICAGO, ILL., Michigan Avenue and 18th Street
CLEVELAND, OHIO, 6300 Euclid Avenue
NEW YORK, N. Y., 292 Madison Avenue at 41st Street (Executive Offices)
PHILADELPHIA, PA., 1315-1317 Race Street
ST. LOUIS, MO., 1014 Olive Street
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

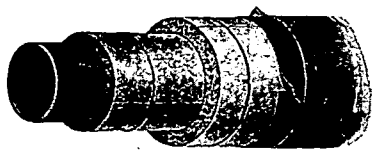
INSULATION SPECIFICATIONS
(Abbreviated Form)



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 per cent 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.	1½"

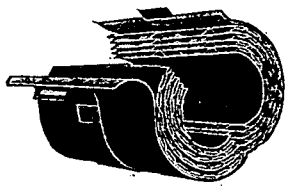


Johns-Manville Superex Combination Insulation

Superheated Steam Piping (Temperatures above 600 deg. fahr.)—All superheated steam piping shall be insulated with Johns-Manville Superex Combination Insulation of thicknesses shown below:

Steam Condition	Temperature Deg. Fahr.	Thickness of Insulation		
		Pipes Larger than 4 in.	Pipes 2 in. to 4 in.	Pipes Smaller than 2 in.
High Superheat	600 to 700	3½"	3"	2"*
High Superheat	700 to 800	4"	3½"	2"*

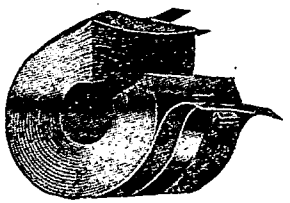
*Single layer Superex Insulation on lines 1½ inch and smaller.



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.

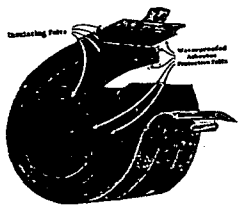


Johns-Manville Asbesto-Sponge Felted Insulation

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	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	257 to 338	1½"	1½"	1"
100 to 200	338 to 388	2"	1½"	1"

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.

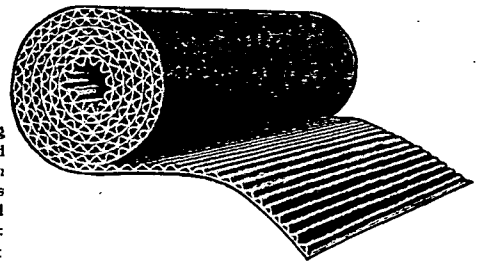


Johns-Manville Anti-Sweat Insulation

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 (In flexible Roll Form)

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.

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 PER CENT 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	891.0
	Std.	Efficiency %	68.7	73.7	77.7	81.1	84.0
	2	" %	78.4	82.0	84.8	87.3	89.5
	3	" %	81.4	84.6	87.0	89.1	90.9
2	0	Bare Pipe Loss, B.t.u.	133.9	331.5	608.3	1003.9	1611.0
	Std.	Efficiency %	76.7	80.5	83.3	85.7	88.2
	2	" %	83.3	85.9	88.2	90.2	91.7
	3	" %	86.2	88.5	90.2	91.9	93.3
3	0	Bare Pipe Loss, B.t.u.	197.3	488.8	896.8	1480.0	2375.0
	Std.	Efficiency %	78.8	82.3	84.8	87.1	89.3
	2	" %	85.2	87.7	89.6	91.4	92.9
	3	" %	88.2	90.2	91.7	93.0	94.2
4	0	Bare Pipe Loss, B.t.u.	253.5	627.9	1152.1	1901.3	3051.0
	Std.	Efficiency %	81.7	84.5	86.9	89.1	90.8
	2	" %	86.4	88.7	90.5	92.1	93.4
	3	" %	89.3	91.1	92.4	93.7	94.8
6	0	Bare Pipe Loss, B.t.u.	371.9	923.7	1694.9	2797.1	4488.5
	Std.	Efficiency %	82.7	85.4	87.6	89.7	91.3
	2	" %	87.8	89.8	91.3	92.8	94.0
	3	" %	90.4	92.1	93.3	94.4	95.3
8	0	Bare Pipe Loss, B.t.u.	485.7	1203.0	2207.3	3642.8	5845.6
	Std.	Efficiency %	83.7	86.2	88.4	90.2	91.9
	2	" %	88.4	90.3	91.8	93.1	94.3
	3	" %	91.1	92.7	93.7	94.8	95.6
Flat Surface	0	(Bare Surface) B.t.u.	215.2	533.0	978.0	1614.0	2590.0
	1	Efficiency %	82.36	85.20	87.60	89.64	91.48
	2	" %	90.16	91.85	93.12	94.27	95.31
	3	" %	93.22	94.37	95.25	96.06	96.75

JOHNS-MANVILLE ASBESTO-SPONGE FELTED INSULATION

For insulating high pressure and superheated steam lines to 750 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	891.0
	1	Efficiency %	76.5	79.9	82.6	85.2	87.4
	2	" %	80.7	83.6	85.8	87.8	90.0
	3	" %	83.5	86.1	88.0	89.8	91.5
2	0	Bare Pipe Loss, B.t.u.	133.9	331.5	608.3	1003.9	1611.0
	1	Efficiency %	80.4	83.3	85.5	87.6	89.3
	2	" %	85.1	87.2	89.0	90.6	92.1
	3	" %	87.7	89.6	91.0	92.4	93.7
3	0	Bare Pipe Loss, B.t.u.	197.3	488.8	896.8	1480.0	2375.0
	1	Efficiency %	82.2	84.9	86.8	88.8	90.3
	2	" %	86.8	88.8	90.3	91.7	93.2
	3	" %	89.5	91.2	92.3	93.5	94.6
4	0	Bare Pipe Loss, B.t.u.	253.5	627.9	1152.1	1901.3	3051.0
	1	Efficiency %	83.3	85.8	87.6	89.5	90.9
	2	" %	87.9	89.7	91.1	92.4	93.7
	3	" %	90.5	92.0	93.0	94.1	95.1
6	0	Bare Pipe Loss, B.t.u.	371.9	923.7	1694.9	2797.1	4488.5
	1	Efficiency %	84.2	86.5	88.3	90.1	91.4
	2	" %	89.1	90.7	91.9	93.1	94.3
	3	" %	91.5	92.9	93.8	94.8	95.6
8	0	Bare Pipe Loss, B.t.u.	485.7	1203.0	2207.3	3642.8	5845.6
	1	Efficiency %	84.8	87.0	88.7	90.4	91.7
	2	" %	89.6	91.2	92.4	93.4	94.6
	3	" %	92.1	93.4	94.2	95.1	95.9
Flat Surface	0	(Bare Surface) B.t.u.	215.2	533.0	978.0	1614.0	2590.0
	1	Efficiency %	84.17	86.50	88.38	90.10	91.73
	2	" %	91.32	92.61	93.61	94.55	95.44
	3	" %	94.02	94.90	95.59	96.23	96.85

JOHNS-MANVILLE IMPROVED ASBESTOCEL INSULATION

For insulating pipes conveying hot water or steam at medium and low pressure.

EFFICIENCIES

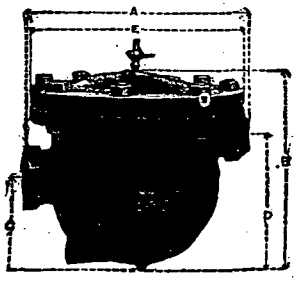
Pipe Sizes Inches	Ply		Temperature Difference Between Pipe and Surrounding Air, Deg. Fahr. 100°	150°	200°	250°	300°
			Temperature of Pipe, Deg. Fahr. (Temperature of Surrounding Air, 75 Deg.) 175°	225°	275°	325°	375°
			Heat losses per linear foot of bare pipe per hour and efficiencies of insulation				
1		Bare Pipe Loss, B.t.u.	74.0	123.8	183.4	253.7	337.4
	2-ply	Efficiency %	57.8	59.8	61.6	63.2	64.8
	3-ply	" %	62.9	64.8	66.6	68.2	69.7
	4-ply	" %	66.4	68.1	69.7	71.2	72.6
2		Bare Pipe Loss, B.t.u.	133.9	223.9	331.5	458.7	608.3
	2-ply	Efficiency %	64.5	66.1	67.6	68.9	70.1
	3-ply	" %	69.7	71.3	72.6	73.9	75.1
	4-ply	" %	73.0	74.5	75.7	76.9	78.0
3		Bare Pipe Loss, B.t.u.	197.3	330.1	488.8	676.3	896.8
	2-ply	Efficiency %	67.2	68.7	70.0	71.2	72.3
	3-ply	" %	72.6	74.0	75.3	76.4	77.4
	4-ply	" %	75.9	77.2	78.3	79.4	80.3
4		Bare Pipe Loss, B.t.u.	253.5	424.2	627.9	868.8	1152.1
	2-ply	Efficiency %	68.6	70.0	71.3	72.4	73.4
	3-ply	" %	74.0	75.3	76.5	77.6	78.6
	4-ply	" %	77.4	78.5	79.6	80.6	81.5
6		Bare Pipe Loss, B.t.u.	371.9	623.9	923.7	1278.1	1694.9
	2-ply	Efficiency %	70.0	71.4	72.6	73.7	74.7
	3-ply	" %	75.6	76.8	77.9	79.0	79.9
	4-ply	" %	79.0	80.1	81.1	82.0	82.8
8		Bare Pipe Loss, B.t.u.	485.7	812.5	1203.0	1664.5	2207.3
	2-ply	Efficiency %	70.9	72.2	73.3	74.4	75.3
	3-ply	" %	76.4	77.6	78.6	79.6	80.5
	4-ply	" %	79.8	80.9	81.8	82.7	83.5

JOHNS-MANVILLE STEAM TRAPS

Type A (Cast Iron)

The simplicity of the Johns-Manville Steam Trap practically eliminates all possibility of its getting out of order. It has and requires no adjustments, and consists of only three parts—the body, discharge bushing and rolling ball, the latter being the only part that moves.

Trap No.	Pipe Size Inches	Capacity Pounds of Water per Hour	Dimensions in Inches (See Diagram) A	B	C	D	E	Weight Lbs.
2-A	3/4	700	7 3/16	6	2 7/8	3 1/4	6 3/4	14 1/4
3-A	1	1000	8 1/4	7 1/8	3 1/2	4 1/2	8	23
4-A	1 1/4	1700	10 7/8	8 3/4	4 1/8	5 1/4	10 1/4	47
5-A	1 1/2	3500	12 1/4	11 1/4	5 5/8	7 1/2	12 1/2	85
6-A	2	6000	14 1/2	13	6 5/8	8 1/8	14 1/4	126



Cast Iron Model

JUNIOR MODEL (Bronze)

For steam pressures to 50 lbs. 1/2 in. outlet and inlet pipe connections. Bushings for pressures from 1 to 10 lbs. and 10 to 50 lbs.

Trap	Pipe Size, Inches	Pressure Range Pounds 1–10	10–50	Capacity, Pounds of water per Hour
Junior	1/2	1–10	10–50	250

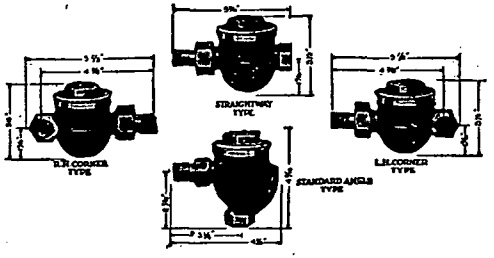
4 1/4 inches long by 3 1/8 inches high; weight, 2 pounds, 6 ozs.

RADIATOR TRAPS (Bronze and Nickel Finishes)

For steam pressures to 10 lbs.—on open (atmospheric) or vacuum return line heating systems. For use on cast iron heating radiators only.

WEIGHTS

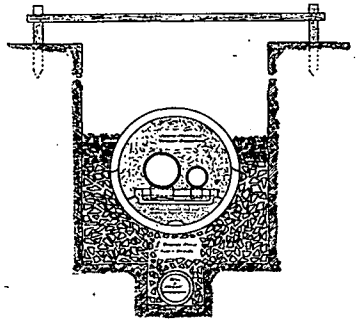
Style	Pipe Connection ½″	Pipe Connection ¾″
Standard	2 lb., 5 oz.	2 lb., 7 oz.
Straight-way	2 lb., 3 oz.	2 lb., 6 oz.
Corner	2 lb., 4 oz.	



Construction Details of the Johns-Manville Underground System of Insulation

Right—Cutaway View of Line



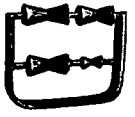


Above—Cross Section of Trench

Below—Two-Pipe Internal Support



Above—Four-Pipe Roll Frame

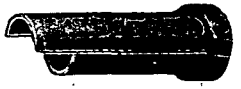




Above—Straight Conduit Section



Above—Three-Pipe Internal Support



Above—Supporting Section Used With Four-Pipe Roll Frame

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.

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.

UNIVERSAL GYPSUM & LIME CO.

Offices

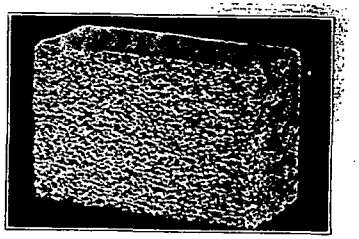
New York, N. Y.
Atlanta, Ga.
Chicago, Ill.
Fort Dodge, Iowa
Kansas City, Mo.

MILLS—Akron, N. Y., Batavia, N. Y., Fort Dodge, Ia., Rotan, Texas

INSULEX
GYPSUM INSULATION

Reg. U. S. Patented Office

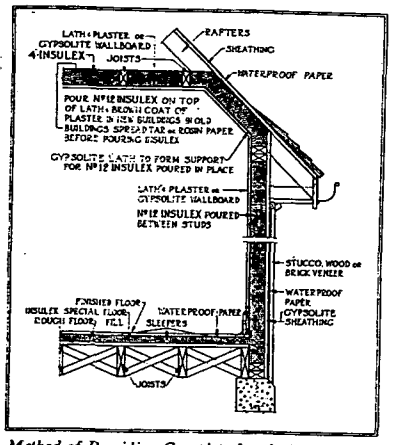
Insulex is a gypsum insulating material for building construction and is used to prevent the passage of heat, cold and sound. When mixed with water **Insulex** expands and hardens into a cellular mass in partitions, floor and ceiling spaces. It is especially adapted for use in homes, apartment



A Block of INSULEX *Showing Cellular Structure*

houses, schools, commercial and industrial buildings where the saving of heat is a vital necessity.

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.



Method of Providing Complete Insulation of House

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.

BUILDING CONSTRUCTION*

SIDE WALL (FRAME)	UNINSULATED		INSULATED By Filling Stud Space With No. 12 INSULEX	
			Lath and Plaster	Gypsolite Plaster Board and Plaster
Clapboard, Stud, Lath and Plaster	....	.345	.082	.079
Clapboard, Paper, Sheathing, Stud, Lath and Plaster	....	.263	.076	.073
Brick Veneer, Paper, Sheathing, Lath and Plaster	....	.251	.075	.073
Cement Stucco, Paper, Sheathing, Lath and Plaster	....	.255	.075	.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
Brick Wall—Plastered Inside:				
8-inch	.379	.272	.111	.105
12- "	.296	.228	.103	.098
16- "	.243	.196	.096	.091
Terra-Cotta Wall—Stucco Exterior—Plastered Inside:				
8-inch	.291	.224	.102	.096
12- "	.225	.183	.093	.088
16- "	.184	.155	.095	.081
CEILING			Filling Space Between Joists 4-Inches With No. 12 INSULEX	
			Lath and Plaster	Gypsolite Plaster Board and Plaster
Ceiling Joists, Lath and Plaster	....	.692	.082	.079

***New Heating Constants**—For use in determining house heating radiation requirements when insulated with **Insulex**, according to Universal Gypsum & Lime Co.'s specifications.

The Armour Institute of Technology, Chicago, Illinois, have prepared the above figures based on tests and years of experience showing the amount of heat lost through various kinds of construction. Prepared by Professor J. C. Peebles.

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.

Chamberlin Metal Weather Strip Company

Incorporated

General Offices: Detroit, Mich.

FACTORIES

Detroit, Mich. **Peru, Illinois**

DISTRICT BRANCHES

Atlanta, Ga.	Cleveland, Ohio	Kansas City, Mo.	Philadelphia, Pa.
Baltimore, Md.	Denver, Colo.	Los Angeles, Calif.	Pittsburgh, Pa.
Boston, Mass.	Detroit, Mich.	Louisville, Ky.	St. Louis, Mo.
Buffalo, N. Y.	Flint, Mich.	Minneapolis, Minn.	South Bend, Ind.
Chicago, Ill.	Indianapolis, Ind.	Nashville, Tenn.	Terre Haute, Ind.
Charlotte, N. C.	Jacksonville, Fla.	New York, N. Y.	Washington, D. C.
Cincinnati, Ohio			Wilkes-Barre, Pa.

Eighty Other Branches Throughout the United States

In order to measure weather strip efficiency it is much more important for the Heating Engineer, the Architect, the Contractor and the Consumer to know what the result of a weatherstrip installation will be at the end of THIRTY or more years than to know the result obtainable immediately after installation.



What Chamberlin Weather Strip **will do** can be determined by a review of what Chamberlin has done for thirty-three years. Installations made in 1893 are still giving service and satisfaction and the same fundamental principles are incorporated in Chamberlin installations made at the present time.

The Test of Time

From time to time field tests are made of Chamberlin installations. The results obtained by engineers on some representative installations are given in the following tables. Tests were made by putting an air collecting chamber on the inside of the window opening and taking anemometer readings over a period of thirty minutes.

Constantly Improved

Chamberlin has been the Standard weather strip since 1893. Thirty-three years have proven the basic principles of Chamberlin, but improvements in design and installation methods have been added whenever the Company's constant research developed a better way.

Life of Building Service Policy

There are only two parties to a Chamberlin installation contract. the customer and the Chamberlin Company. Chamberlin manufactures, sells, installs and services every installation by means of a complete organization of trained men. Results, not material alone, are insured by the Company's

service guarantee which remains in effect for the "life of the building." That is why the purchase or recommendation of Chamberlin becomes a specification of guaranteed service and not of material. Chamberlin Metal Weather Strip is the only building product sold and guaranteed in this way.

No Heating Plant Can Do It All

The best heating plant in the world can't heat the whole outdoors and that is just what is expected of every heating plant when installed in a building where windows and doors are not weatherstripped. Heating engineers should recognize the value of preventing heat loss rather than attempt to design a heating plant to take care of any loss no matter how great. Therefore, Chamberlin cooperation and the completeness of Chamberlin service merits prime consideration in the computations of the careful engineer, architect and builder.

CHAMBERLIN TESTS OF TIME

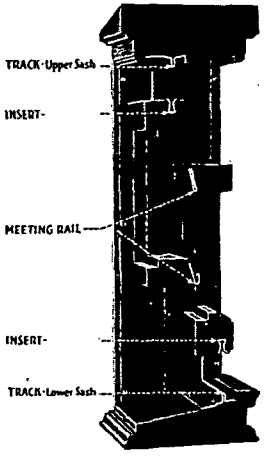
Name of Building	Location and Date of Chamberlin Installation	Date of Test	Size of Window (Lin. Ft. of Crack)	Wind Velocity, M. P. H. U. S. Weather Bureau	Leakage Without W. S. Based on A. S. H. & V. E. Test	Leakage on Date of Test Including Frame and Pulley Leak	Percentage of Possible Leakage Kept Out
E. A. De Wolfe Res.	St. Louis, 1893	3/ 7/25	18.80	25	78.88	.53	99.3
Equity Bldg.	Detroit, 1894	12/17/24	23.85	24	96.04	5.05	93.70
Majestic Bldg.	Detroit, 1896	12/11/24	34.00	8	46.25	1.79	95.91
Majestic Bldg.	Detroit, 1896	12/12/24	34.00	12	68.38	4.22	93.86
Union Trust Co. Bldg.	Cincinnati, 1901	3/20/25	26.00	15	72.30	7.00	90.32
Adolphus Busch Res.	St. Louis, 1903	3/ 7/25	18.25	21	66.79	2.51	96.20
Horace Mann School	New York, 1903	4/11/25	20.67	7.5	28.23	1.87	93.38
City Hall	Detroit, 1904	12/ 3/24	30.67	9	44.36	7.31	83.52
Michael Reese Hosp.	Chicago, 1906	2/15/25	32.00	12	66.10	10.65	83.90
Congress Hotel	Chicago, 1906	2/11/25	25.33	15	63.70	4.00	93.70
Detroit Club	Detroit, 1906	12/ 2/24	26.50	8	35.28	4.19	88.41
Fleming Bldg.	Des Moines, 1906	2/17/25	25.33	6	23.30	2.50	89.30
D'Youville College	Buffalo, 1907	4/ 3/25	27.00	18	83.15	4.98	94.00
Owen Bldg.	Detroit, 1907	12/ 6/24	28.00	18	87.00	4.42	94.92
Ford Bldg.	Detroit, 1908	11/27/24	26.50	12	53.30	5.01	90.60
Boston College	Newton, Mass., 1910	4/10/25	20.67	12.5	47.60	3.34	92.40
Campau Bldg.	Detroit, 1910	12/ 3/24	25.50	10	47.23	5.00	89.44
Hosp. Rockefeller Inst.	New York, 1910	4/ 9/25	19.50	14	46.29	3.66	92.10
Cleveland Ath. Club	Cleveland 1911	4/ 2/25	31.50	20	109.70	6.30	94.16
Copley Plaza Hotel	Boston, 1912	4/10/25	20.33	12	44.40	1.18	97.34
Hubbell Bldg.	Des Moines, 1912	2/16/25	26.00	7.5	29.25	4.26	85.00
Pharmacy Bldg.	U. of Minn., 1912	2/23/25	25.33	8	38.10	3.00	92.13
Dime Sav. Bk. Bldg.	Detroit, 1913	11/28/24	26.50	22	90.15	9.93	87.60
Board of Commerce	Detroit, 1913	12/10/24	21.00	12	42.13	1.98	95.28
Kresge Bldg.	Detroit, 1914	12/ 9/24	27.85	28	132.76	17.53	86.80
Kresge Bldg.	Detroit, 1914	12/ 9/24	27.85	24	112.15	15.47	86.21
David Whitney Bldg.	Detroit, 1915	11/25/24	28.50	19	92.65	5.00	94.60
Det. Athletic Club	Detroit, 1915	12/13/24	20.67	14.5	49.82	5.35	89.26
Peter Smith Bldg.	Detroit, 1916	12/11/24	19.85	16	53.17	3.76	92.93
Fort Shelby Hotel	Detroit, 1918	12/ 5/24	23.33	13	50.73	6.96	86.28
Field Museum	Chicago, 1919	2/26/25	24.17	16.5	66.20	5.65	91.48
Planters Bldg.	St. Louis, 1919	3/ 7/25	26.70	18	83.75	6.41	92.30
Park Ave. Bldg.	Detroit, 1922	12/10/24	26.85	21	96.46	3.23	96.80
Int'l. Shoe Co. Bldg.	St. Louis, 1923	3/ 6/25	29.00	15	74.26	2.55	96.60

The Higgin Manufacturing Co.

NEWPORT, KY.

Manufacturers of Metal Weather Stripping for Windows and Doors

Representatives in Principal Cities



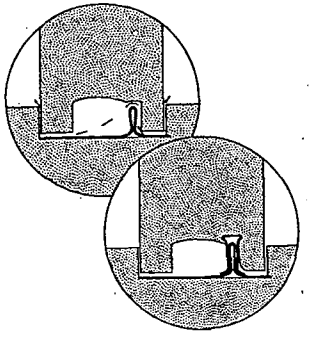
The Higgin All-Metal Weather Strip Equipment effectually reduces to a minimum infiltration losses around windows and doors.

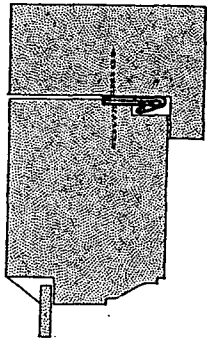
Double Hung Windows: The Higgin Two-Member Track and Insert Equipment for double hung windows consists of a rib track, zinc or copper, fitted to the window frame. The rib or raised portion is ⅜ in. high and extends into a groove cut into the edge of sash.

The Insert, usually made of bronze, very thin gage is of spring temper and is fitted and concealed into the groove in the edge of sash. It is so formed that the spring sides or flanges contact with the tongue or rib of the track. These two contacting metals seal the aperture around the edge of the sash. The insert resting on the slightly raised portion at base of rib on track insures easy sliding.

Sash Shrinkage: Air leakage can occur in around the tongue of a track strip working loosely in a groove in wood sash. The efficiency of the Higgin Two-member Track and Insert is not affected by shrinkage of the sash. If sash should draw away from frame, the Insert will snugly contact with the rib at any point of its projection. Air leakage through the pulley holes, is prevented by the Insert, dividing as it does into a separate chamber the cut out space for sash cord.

Installation: *Lower Sash*—The rib track extends to top edge of meeting rail projecting slightly into the parting strip and also lapping under inside stop. *Upper Sash*—The rib track extends about one inch below meeting rail, projecting slightly into the outside stop bead. Slot is cut into track to clear pulleys. *Head and Sill*—Track extends full width of opening. Insert concealed in sash groove, at sides, bottom and head, full length. The meeting rail is equipped with a flat zinc or copper strip





attached to top rail of lower sash which interlocks with a hook strip attached to the bottom rail of the upper sash.

Casement Windows: The top and lock sides are equipped with a flat zinc or copper strip attached to sash which interlocks with a hook strip of same metal, secured into the rabbet. The hinged side, a rib track is applied, the raised tongue extending into a groove in the sash. The bottom of out-opening sash are usually equipped the same as for top and lock sides. In-opening sash are equipped with an interlocking trough of either brass or zinc. This equipment has proven very efficient in stopping air and water leakage.

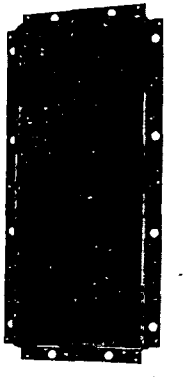
Doors: In the rabbet at sides and head are attached a compression spring bronze strip which contacts with door as it closes. For the bottom an extruded brass threshold with an interlocking brass hook and spring bronze contact strip makes a thoroughly air and water-tight equipment and provides a handsome and permanent threshold.

Catalogue upon request. We will contract to install Higgin All-Metal Weatherstrips in new or old buildings. Estimates gladly furnished.

HIGGIN ALL-METAL ACCESS PANEL

Higgin Flush Metal Access Panels are neat in appearance, easily installed and provide easy and inexpensive access to critical points in heating or plumbing systems, refrigerator pipes, valves or any place where immediate access and neat inconspicuous appearance is desired.

The **Higgin** frame and panel is made as a unit of heavy gauge metal. Installation is easily and quickly accomplished. When access is desired there are no screws or locks to bother with. A screw driver or knife springs the panel out leaving the opening clear with a maximum of working space. Panels may be papered or painted over so that they will be invisible.



Higgin Metal Access Panels are made in three sizes, 7¼″ x 11½″, 18″ x 24″ and 7¼″ x 18″. The latter size has been especially designed for access to expansion joints in heating systems. The narrow width permits installation in limited space but still provides ample room for working.

Write for descriptive folder and details.

The Westinghouse Electric & Manufacturing Company

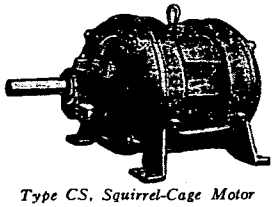
EAST PITTSBURGH, PA.

WESTINGHOUSE SALES OFFICES

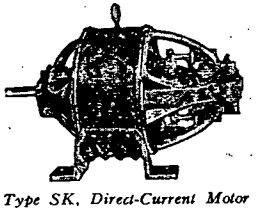
Abilene, Kan.
Abilene, Tex.
Albany, N. Y.
*Atlanta, Ga.
Bakersfield, Calif.
*Baltimore, Md.
Birmingham, Ala.
Bluefield, W. Va.
*Boston, Mass.
Bridgeport, Conn.
*Buffalo, N. Y.
Burlington, Iowa
*Butte, Mont.
Canton, Ohio
Casper, Wyo.
Cedar Rapids, Iowa
Charleston, W. Va.
*Charlotte, N. C.
Chattanooga, Tenn.
*Chicago, Ill.
*Cincinnati, Ohio
*Cleveland, Ohio
*Columbus, Ohio
*Dallas, Tex.
Davenport, Iowa
Dayton, Ohio
*Denver, Colo.
Des Moines, Iowa
*Detroit, Mich.
Duluth, Minn.
Elmira, N. Y.
*El Paso, Tex.
Erie, Pa.
Evansville, Ind.
Fairmount, W. Va.
Fort Wayne, Ind.
Fresno, Calif.
Grand Rapids, Mich.
Hammond, Ind.
Hartford, Conn.
*Houston, Tex.
*Huntington, W. Va.
*Indianapolis, Ind.
Ishpeming, Mich.
Jackson, Mich.
Jackson, Miss.
Jacksonville, Fla.
Johnstown, Pa.
Joplin, Mo.
*Kansas City, Mo.
Knoxville, Tenn.
Little Rock, Ark.
Louisville, Ky.
*Los Angeles, Calif.
Madison, Wis.
Marshall, Tex.
Medford, Ore.
Memphis, Tenn.
Miami, Fla.
Middlesboro, Ky.
Milwaukee, Wis.
*Minneapolis, Minn.
Mobile, Ala.
Nashville, Tenn.
Newark, N. J.
New Haven, Conn.
*New Orleans, La.
*New York, N. Y.
Niagara Falls, N. Y.
Norfolk, Va.
Oklahoma City, Okla.
Omaha, Neb.
Peoria, Ill.
*Philadelphia, Pa.
*Phoenix, Ariz.
Pine Bluff, Ark.
*Pittsburgh, Pa.
Portland, Maine
Portland, Ore.
Poughkeepsie, N. Y.
Providence, R. I.
Pueblo, Colo.
Raleigh, N. C.
Richmond, Va.
Rochester, N. Y.
Rockford, Ill.
Rutland, Vt.
Saco, Maine
*Salt Lake City, Utah
San Antonio, Tex.
San Diego, Calif.
*San Francisco, Calif.
*Seattle, Wash.
Shreveport, La.
Sioux City, Iowa
South Bend, Ind.
Spokane, Wash.
Springfield, Ill.
Springfield, Mass.
*St. Louis, Mo.
Syracuse, N. Y.
Tacoma, Wash.
*Tampa, Fla.
Terre Haute, Ind.
Toledo, Ohio
Tulsa, Okla.
*Utica, N. Y.
Washington, D. C.
Watertown, N. Y.
Wilkes-Barre, Pa.
Worcester, Mass.
Youngstown, O.
The Hawaiian Electric Co., Ltd., Honolulu, T. H.—Agent.

*Warehouse located in this city.

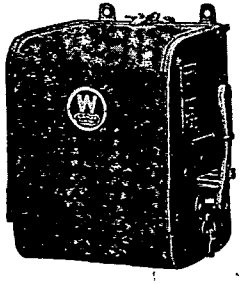
MOTORS AND CONTROL FOR HEATING, VENTILATING AND AIR CONDITIONING SYSTEMS



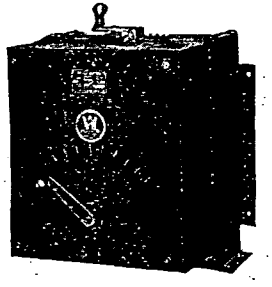
Type CS, Squirrel-Cage Motor



Type SK, Direct-Current Motor



Class 10700 Auto Starter



Class 7210-B Regulator

Motors—Westinghouse motors and control can be supplied for practically all demands within the heating and ventilating engineer's field of activity. Noiseless operation, close speed regulation, and dependability in service are their recognized characteristics.

Motor Control—Westinghouse Electric manufactures manual and magnetic starters and speed regulators to control motors in all applications. By specifying Westinghouse starters and regulators to operate Westinghouse motors, the responsibility for the successful operation of the installation is placed upon one manufacturer.

Buffalo Steam Pump Co.

Buffalo, N. Y.

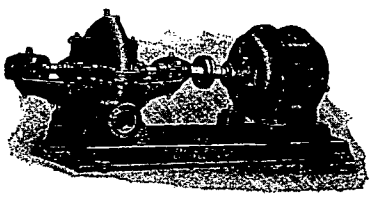
BRANCH OFFICES

NEW YORK, N. Y., 39-41 Cortlandt St.
PHILADELPHIA, PA., 1302 Land Title Bldg.
BOSTON, MASS., 10 Milk St.
CLEVELAND, O., 368 Rockefeller Bldg.
PITTSBURGH, PA., 927 Union Trust Bldg.
DETROIT, MICH., Coon-DeVisser Co.
CHICAGO, ILL., 562 W. Washington Blvd.
WASHINGTON, D.C., 418 Washington Loan & Trust Bldg.
ATLANTA, GA., Candler Bldg.
INDIANAPOLIS, IND., 725 Continental Bank Bldg.
ST. LOUIS, MO., 515 Chemical Bldg.
CINCINNATI, O., 604 Mercantile Library Bldg.
MINNEAPOLIS, MINN., 430 Oak Grove St.
LOS ANGELES, CALIF., 220 Black Bldg.
CHARLOTTE, N. C., J. W. Fraser & Co.
NEW ORLEANS, LA., Woodward Wight & Co.
SAN FRANCISCO, CALIF., 307 Flatiron Bldg.
SEATTLE, WASH., 905 Olympic Way

CANADIAN BLOWER AND FORGE CO., Kitchener, Ont.

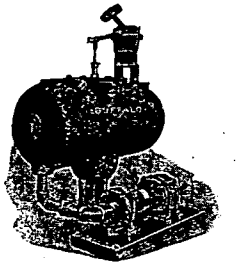
Products

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.



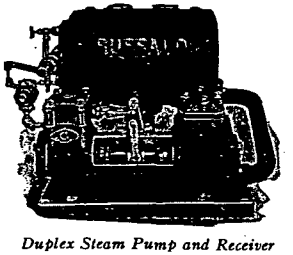
Class S Double Suction Centrifugal Pump

Horizontally divided casing. Extensively used with air washers, and for circulating systems and booster service.



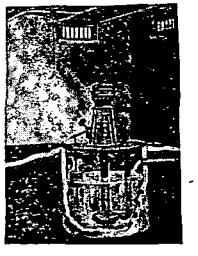
Centrifugal Condensation Return Pump and Receiver

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.



Automatic Sump Pump

Self contained. Ball bearing thrust with automatic oil lubrication.

COMPLETE CATALOGS WILL BE FURNISHED UPON REQUEST

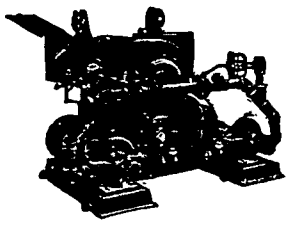
Economy Pumping Machinery Co.

98-124 N. Curtis St., CHICAGO — **Works, JOLIET, ILL.**

Sales Offices

New York City, N. Y., 39 Cortland St.
Grand Rapids, Mich., Shepard Bldg.
W. Montreal, Quebec, Can., 246 Craig St.
Kansas City, Mo., 207 Davidson Bldg.
Wichita, Kans., 421 Sedgwick Bldg.
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Indianapolis, Ind., Board of Trade Bldg.
Philadelphia, Pa., 604 Arch St.
Chattanooga, Tenn., 823 Chestnut St.
New Orleans, La., 415 Gravier St.
Detroit, Mich., 517 E. Larned St.
Baltimore, Md., 15 E. Fayette St.
Des Moines, Iowa, 512 Hubbell Bldg.
San Francisco, Cal., Mondanock Bldg.
Amsterdam, N. Y., 447 Guy Park Ave.
Toledo, Ohio, 2940 Broadway
Cincinnati, Ohio, 309 Main St.
Pittsburgh, Pa., Fulton Bldg.
Oklahoma City, Okla., 710 N. Hudson St.
Milwaukee, Wis., 616 Caswell Block
Seattle, Wash., 309 Crown Bldg.
Portland, Ore., Worcester Bldg.
South Bend, Ind., 312 Lincoln Way
St. Paul, Minn., 503 Hamm Bldg.

Economy Centrifugal Return Line Vacuum Pump and Boiler Feeder



Type 2234

Economy vacuum pumps remove air and condensation from the heating system automatically discharging the water to boiler. Their flexibility imposes no limitations on capacity or pressure. Reasonable delivery is made on pumps designed to discharge against 100 lb. boiler pressure. Units rated over 5000 sq. ft. capacity have bronze fitted horizontal split case, double suction pumps with perfectly balanced rotors. All standard units are supplied with bronze suction strainer scale pocket and automatic control all firmly mounted on cast iron base. Wiring is in conduit to conform with Underwriter's rules. Each pump tested and ready for operation when delivered.

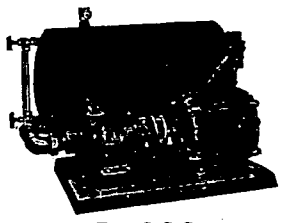
Economy Centrifugal Vacuum Pump

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	.....

Duplex units consisting of single tank, two pumps, motors and control apparatus will approximate 75 per cent addition to the weights above listed.

Economy Pumps and Receivers

Made in variety of forms to meet every requirement.

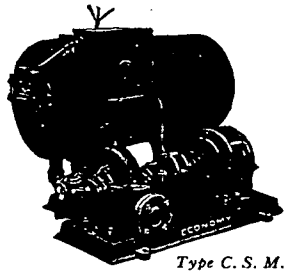


Type C. S. S.

C. S. S. type pumps and receivers are made for standard low boiler pressure work up to 25 lbs. The pump is bronze fitted single side suction type with oil-less sleeve bearing at pump and ring oiling bearing. Also has ball thrust bearing and flexible coupling. Crank action, float mechanism operated by copper float insures positive operation for enclosed switch. Mounted on heavy cast iron base the units are fully assembled, ready for operation. We have a proper size pump for every job. Cracked boiler sections eliminated when Economy Pumps are used. Receivers and pump capacities proportioned to prevent excessive low water conditions of boiler.

No. of Unit	Capacity in Sq. Ft. Direct C. I. Radiation	Discharge Pressure, Lbs. per Sq. In.	Motor H. P.	Pump Capacity C. P. M.	Receiver Capacity Gallons	Gals. Condensate per Min. at 0.25 Lbs. Sq. Ft. Hr.
6	2,000	10	¼	7½	13	1
6½	3,500	10	⅓	12	16	1¾
7	5,000	10	½	15	20	2½
7A	5,000	15	¾	15	20	2½
7B	5,000	20	1	15	20	2½
7½A	7,500	10	½	20	26	3¼
7½	7,500	15	¾	20	26	3¼
7½B	7,500	20	1	20	26	3¼
8A	10,000	10	½	25	33	5
8	10,000	15	1	25	33	5
8B	10,000	25	1½	25	33	5
8½A	15,000	10	¾	37	41	7½
8½	15,000	15	1	37	41	7½
8½B	15,000	25	2	37	41	7½
9A	25,000	10	1	60	49	12½
9	25,000	15	2	60	49	12½
9B	25,000	25	3	60	49	12½
9½A	35,000	10	1½	80	70	17½
9½	35,000	15	2	80	70	17½
9½B	35,000	25	3	80	70	17½
10	50,000	15	2	110	82	25
10A	50,000	25	5	110	82	25
10B	50,000	35	5	110	82	25

Economy Pumps and Receivers C. S. M. Type

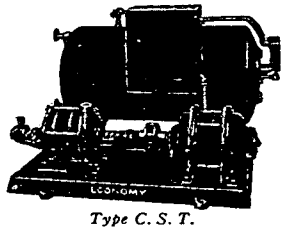


Type C. S. M.

The demand for an unusually high-grade pump and receiver has caused us to make available a complete line of sizes from 5,000 to 50,000 sq. ft. capacity, inclusive. These units include horizontal split double suction bronze fitted pumps with double ring oiling bearings; a heavy receiver, our special float mechanism, switch and a self-starter for the motor. These units are designed to discharge against boiler pressures up to 55 lbs. They are made both single and duplex pump units.

Economy S. S. T. Type

Made in both single and duplex form.



Type C. S. T.

These units are the same as C. S. M. except the pumps are multi-stage vertical split bronze fitted, double outboard ring oil bearings made in sufficient number of stages to discharge against boiler pressures from 25 to 150 lbs.



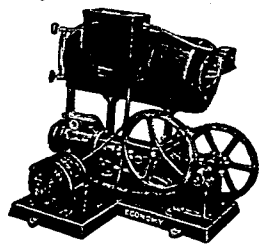
Type C. U.

Economy Underground Pump and Receiver C. U.

Intended for work where radiation is placed on the floor with returns underground. They consist of a special pump and float switch mechanism which prevents binding and sticking of float rods. Made in sizes of 2,000 to 50,000 sq. ft. radiation capacity for either 10 or 20 lbs. boiler pressure. Receiver is cast iron, stuffing box around pump shaft, thrust carried on ball bearing in cage above stuffing box. The lower bearing is of oil-less sleeve type.

Economy Reciprocating Pump—C. R. Type

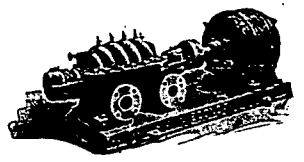
Pump and receiver for work up to 125 lbs. boiler pressure.



Type C. R.—Pump and Receiver

These units are frequently used in old remodelled jobs, comprising several types of heating systems. They will handle the condensate from all and sometimes are used to establish a vacuum in parts of the apparatus. This feature is not automatic or capable of close adjustment. Silent chain drive is used. Pump is fully bronze fitted and made for capacities ranging from 1,250 to 25,000 sq. ft. radiation.

Economy Boiler Feed and High Pressure Pumps



Type E. M. F.

This is a single suction multi-stage horizontally split case centrifugal pump intended for heads up to 800 ft. or boiler pressures up to 350 lbs. It is hydraulically balanced, fully bronze fitted, having a high operating efficiency and low maintenance cost, made for any type drive, direct connected motor or turbine; belt or silent chain as desired. Impellers are cast bronze one-piece, accurately balanced, keyed and locked on alloy steel, ground shaft between threaded bronze sleeves. Stuffing boxes are water sealed type, bearings are ring oiling, split sleeve type machined all over, oil level gauges and spring hinged cover inspection ports are provided.

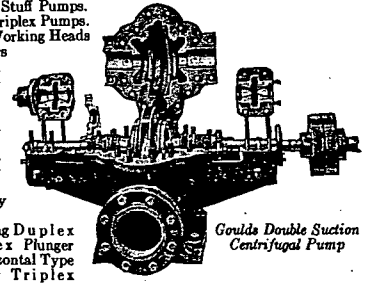
Goulds Pumps, Inc.

PUMP MAKERS SINCE 1848

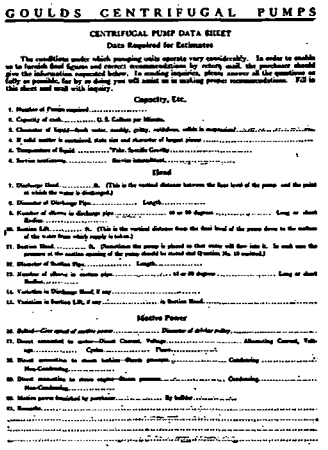
BRANCHES		MAIN OFFICE AND WORKS	BRANCHES	
Atlanta	Boston	SENECA FALLS	Chicago	Pittsburgh
New York	Philadelphia	New York	Tulsa	Houston

GOULDS PUMPS have been made for every service for more than three-quarters of a century and have an established reputation for reliable service, economy in operation, and conservative rating. Bulletins on power pumps give complete specifications of the standard types as follows:

No. 100. Double-Acting, Single Cylinder Piston Pumps.
No. 101. Single-Acting Triplex Plunger Pumps, Outside-Guided Type.
No. 103. Single-Acting Triplex Plunger Pumps, Large Capacity and High Pressure Types.
No. 104. Double-Acting Triplex Piston Pumps, Vertical Type.
No. 105. Single Stage, Single Side Suction Centrifugal Pumps.
No. 106. Vacuum and Stuff Pumps.
No. 107. Deep Well Triplex Pumps.
No. 108. Deep Well Working Heads and Cylinders
No. 110. Single Stage, Double Suction Centrifugal Pumps.
No. 111. Centrifugal Sump Pumps
No. 112. Handy Data on Power Pumping.
No. 113. Power Rotary Pumps.
No. 115. Double-Acting Duplex and Triplex Plunger Pumps, Horizontal Type
No. 116. Single-Acting Triplex Pressure Pumps.
No. 118. Centrifugal Fire Pumps.
No. 119. Single Stage, Single Suction Centrifugal Pumps, Enclosed Impeller Type.
No. 120. Multi-Stage Centrifugal Pumps for General Service.
No. 122. Centrifugal Pump Data.
No. 124. Installation—Operation—Inspection, Goulds Centrifugal Pumps.
No. 125. Single Stage, Double Suction Centrifugal Pumps.



Goulds Double Suction Centrifugal Pump


GOULDS CENTRIFUGAL PUMPS

CENTRIFUGAL PUMP DATA SHEET

Data Required for Estimates

Pump Data

Several units of interest to heating engineers and architects are shown here accompanied by data on capacity, speed, efficiency which will assist them in choosing the right Goulds pump for the service desired.

GOULDS DOUBLE SUCTION CENTRIFUGAL PUMPS are the results of over 12 years of research and progressive development and are of exceptionally high efficiences.

CASING.—Close grained iron, divided horizontally, the two castings bolted together. The lower half of the bearing housings are cast integral with the lower half of casing. Casing is provided with air cocks, and with openings for priming and draining.

IMPELLER: Cast iron, accurately machined and balanced.

BEARINGS: Ring oiling type with split cast iron shells lined with babbit, supported in horizontally divided housings securely locked against rotation or lateral motion. Shells are removable without disturbing rotating element.

THRUST BEARINGS: All pumps are provided with a self-aligning double-acting ball thrust bearing, running in an oil bath, which takes care of any unbalanced thrust due to uneven wear of sealing surfaces.

SHAFT: Special alloy steel, heat treated, accurately machined to gauge.

STUFFING BOX: Of extra long design with brass water seal ring and water seal piping.

GLANDS: The glands are split horisontally, permitting the gland to be removed and affording maximum space for repacking. They are adjusted by swing bolts.

CASING WEARING RINGS: Casing is equipped with bronze wearing rings, which can be renewed as required, thus keeping the clearances to a minimum.

IMPELLER WEARING RINGS: Wearing rings on bronze impellers can be furnished as an extra.

Table of Capacities for Goulds Centrifugal Pumps

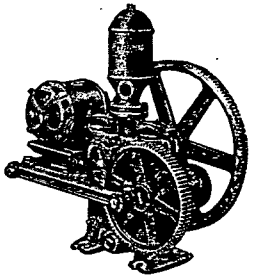
Figure No.	Pump No.	Pipe Sizes: Discharge In.	Pipe Sizes: Suction In.	Approx. Capacity Gals. per Min.: Minimum	Approx. Capacity Gals. per Min.: Maximum	Standard Pulleys: Diameter In.	Standard Pulleys: Face In.	†Approx Domestic Shipping Weight Lb.
3065	5	5	6	400	800	8	8	1020
	6	6	8	600	1300	10	10	1325
	8	8	10	1000	2700	12	12	2100
	10	10	12	2000	4400	12	12	3300
3075	5	5	6	400	900	8	8	1275
	6	6	8	600	1500	10	10	1605
	8	8	10	1100	2900	12	12	2525
3085	2	2	3	50	325	5	5	600
	3	3	4	150	350	6	6	950
	4	4	5	250	750	8	8	1270
	5	5	6	400	1000	10	10	1520
	6	6	8	800	1700	12	12	2400
	8	8	10	1300	3000	12	15	3425
3095	2	2	3	50	250	6	6	1020
	3	3	4	200	450	8	8	1120
	4	4	5	400	800	10	10	1585
	6	6	8	500	2000	12	12	2900

†Weight includes either bedplate and coupling for direct connected drive or bedplate, pulley, pulley shaft, coupling and two pedestal bearings for belt drive.

FLEXIBLE COUPLING: A flexible coupling of the pin-and-buffer type is provided to connect the pump to prime mover or belt pulley shaft.

BED PLATE: Pump and prime mover are mounted on a rugged cast iron bedplate of neat design, with a drip canal around the four sides.

Goulds "Pyramid" Double-Acting Piston Pump (Fig. 1678) is especially adapted for handling Condensation of Steam Heating Systems and for General Water Supply, Mine Service and Hot Water Pumping. Built in a single iron casting embodying the base, cylinder, bearings and one cylinder head, with the cylinder fitted with a renewable cast bronze lining and the piston fibrous packed, this pump is of strong and rigid construction.



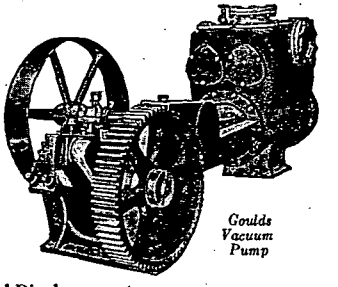
Goulds Pyramid Piston Pump

Dimensions, Speeds, Displacements, Goulds "Pyramid" Pump Ratings Based on Pumping Cold Water.

Pistons: Diam.	Pistons: Stroke	Displ. per Rev. of Crank Shaft, Cal.	Usual Speed and Displacement per Min.: Rev.	Usual Speed and Displacement per Min.: Gal.	Horse Power at Catalog Rating	Horse Power for Vacuum Service	†No. Sq. Ft. Heating Radiation	Size Pipe: Suction In.	Size Pipe: Discharge In.	Geared	Pulleys Tight and Loose In.	Weight Lb.
2¼	4	.130	39	5	.50	.50	700	1¼	1¼	5 to 1	8x2½	170
2¼	5	.245	41	10	1.00	.50	1450	1½	1½	5 to 1	15x2½	295
3¼	5	.465	39	18	1.50	1.00	2600	2	2	5 to 1	15x3	340
4¾	5	.741	38	28	3.00	1.00	4000	2½	2½	5 to 1	16x4	525
5¾	6	1.316	38	50	5.00	1.50	7000	3	3	5 to 1	20x4	680

†Figures based on the condensation of one-third of a pound of steam per square foot of radiating surface per hour, which is a good average condition.

Goulds Double-Acting Piston Vacuum Pump (Fig. 1049) has a displacement of 10,200 gal. to 81,000 gal. per hr. The waterways are so constructed that the valves at both ends of the cylinder are always submerged. The frame is of cast iron in one piece bolted to the cylinder, supporting the bearings and crosshead guides. These pumps are designed for Suction Box on Paper Machines, Vacuum Pans, Surface Condensers, and Vacuum System of Steam Heating.



Goulds Vacuum Pump

Goulds Vacuum Pump—Dimensions and Displacements

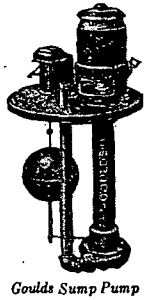
Gallons Displacement per Min.	Pistons: Diam. In.	Pistons: Stroke In.	Displacement 1 Rev. of Crank Shaft	Vacuum Steam Heating Systems: H. P. Required	Vacuum Steam Heating Systems: *Sq. Ft. of Radiation	R. P. M.	Sizes of Pipes: Suction In.	Sizes of Pipes: Discharge In.	Geared	Single Pulley In.
170	8	10	4.28 gal.	3	24500	40	5	5	4 to 1	30x4
265	10	10	6.73 "	5	38000	40	5	5	4 to 1	30x5
385	12	10	9.72 "	5	55000	40	5	5	4 to 1	30x5
525	14	10	13.22 "	7½	75500	40	6	6	4 to 1	30x5
700	14	14	18.51 "	10	100000	38	6	6	4 to 1	36x6
1000	16	16	27.62 "	10	144000	37	8	8	4 to 1	36x6
1350	18	18	39.31 "	15	194500	35	10	10	4 to 1	42x8

*Figures based on the condensation of one-third of a pound of steam per square foot of radiating surface per hour, which is a good average condition.

The Goulds Sump Pump (Fig. 3029) is a standardized outfit built in one size. Ratings for this size are given below. When the sump is full the float rises and actuates the switch which in turn starts the motor. When sump is drained, the float falls and the motor is stopped. Electric current is used only when pump is running and the pump is always submerged ready to start work instantly.

Ratings—Fig. 3029 Sump Pump

	with ¼ H.P.—1725 R.P.M. Motor						with ¼ H.P.—1450 R.P.M. Motor					
Gals. per Min.	10	15	20	25	30	35	12	15	20	25	30	
Head in Ft.	24	22	20	18	16	13	15	14	13	11	8	



Goulds Sump Pump

Chicago Pump Company

Office and Works

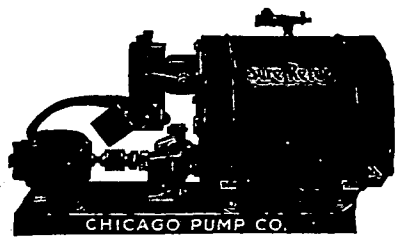
2330 Wolfram Street - - CHICAGO, ILL.

Representatives in Principal Cities

Quality Centrifugal Pumps—{Condensation, Vacuum, Sump, Sewage, House Circulating, Fire

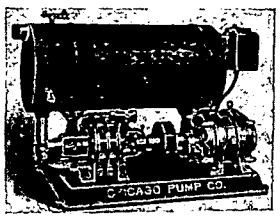
HORIZONTAL CONDENSATION PUMP AND RECEIVER

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

The "Sure Return" condensation pump and receiver is especially designed for low and medium capacities and boiler pressures up to 10 lbs. All parts are standard and interchangeable. Delivery can be made on this unit in 24 hours. Bulletin 131.



F. C. Condensation Pump

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

Unit No.	Maximum Sq. Ft. Direct Radiation	Horsepower Motor	Approximate Floor Space Required Inches	Highest Water Level in Receiver from Floor Line Inches
H. 650	3,000	¼	43x28	26
H. 651	6,000	½	43x30	26
H. 652	10,000	½	55x30	30
H. 653	15,000	¾	57x32	30
H. 654	20,000	¾	59x32	30
H. 655	25,000	1	59x32	35
H. 656	35,000	1	61x34	39
H. 657	50,000	1½	65x36	41

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.

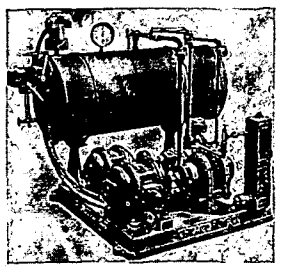
Unit No.	Maximum Sq. Ft. Direct Radiation	Lbs. Press. Pump will Disch. Against	Horsepower Motor Furnished	Capacity Pump in Gals. per Min.	Dia. Receiver, In.; also Floor Space
1650	3,000	10	½	5	24
1651	"	17	¾	"	"
1652	"	22	1	"	"
1654	6,000	10	½	10	24
1655	"	17	¾	"	"
1656	"	22	1	"	"
1658	10,000	10	½	15	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

RETURN LINE VACUUM HEATING PUMP AND RECEIVER

The "Condo-Vac" return line vacuum pump and receiver for maintaining a vacuum on the return line of a heating system and collecting and returning the condensation to the boiler, is constructed with separate motors and individual automatic control. The entire outfit is mounted on one base. Units for capacities from 5000 to 6500 sq. ft. of direct radiation, low and high boiler pressures. Bulletin 137.



Return Line Vacuum Pump

ENGINEERING SERVICE

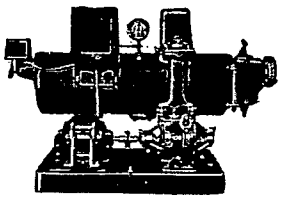
The cooperation and advice of skilled engineers will be gladly given to Engineers, Architects, and Contractors in the solution of their pump problems. Complete data are available in bulletins on all types of pumps.

The Nash Engineering Company

South Norwalk, Conn., U. S. A.

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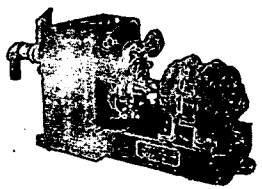
Motor-Driven Return Line Vacuum Pump

Jennings Vacuum Pump for Return Line Heating Systems

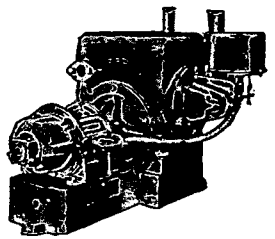
This pump removes air and water from the heating system, discharges the air to the atmosphere without back pressure, and automatically returns the water under pressure to the boiler or hot-well. Air and water are handled independently, often resulting in a 50% saving in horsepower required for pump operation. Occupies one-third the space of other apparatus of equivalent capacity.

Interior parts bronze. Moving parts revolve without metal-to-metal contact and are supported on radial ball bearings mounted outside casing.

Furnished direct connected to standard electric motors, for belt drive, or for steam turbine drive.



Motor-Driven Return Line Vacuum Pump, Size M



Motor-Driven Condensation Pump

Jennings Condensation Pump and Receiver, Unit Type

No piping between the pump and receiving tank is necessary. The only connections are main return, water discharge, and air vent. Companion flanges are furnished.

The pump has an integral cast bronze impeller mounted on motor shaft supported by large motor bearings.

Literature, Recommendations and Proposals on Request

Bulletin 37—Return Line Vacuum Heating Pump.
Bulletin 25—Return Line Vacuum Heating Pump Size M.
Bulletin 18—Return Line Vacuum Heating Pump, Turbine Driven.
Bulletin 29—Condensation Pump.
Bulletin 17—Air-Line Vacuum Heating Pump.
Bulletin 10—Air and Gas Compressors.
Bulletin 11—Air and Gas Vacuum Pumps.
Bulletin 52—Centrifugal Pump.

STANDARD SIZES AND CAPACITIES, JENNINGS VACUUM PUMPS

Size	Square Feet direct equivalent radiation surface	Air Capacity cubic feet per min.	Water Capacity gals. per min. 10 lbs. pres. 180 F.	Actual Horse Power	R. P. M.	Horse Power of Motor for 10 lbs. Discharge
M	5,000	3	8	.6	1700	¾
A	8,000	5	11	.9	1800	1
B	16,000	9	22	1.4	1800	1½
C	26,000	15	35	2.0	1800	2
D	40,000	19	60	2.8	1200	3
E	65,000	34	90	3.9	1200	5
F	100,000	60	140	7.	1200	7½
G	150,000	80	200	9.8	900	10
H	300,000	150	400	19.	720	20

TRANE PUMPING EQUIPMENT

(See Trane Heat Cabinets on pages 394 and 395. Also Trane Heating Specialties on pages 530 and 531.)

The Trane Company

La Crosse, Wis.

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New York, Chicago, Boston, Cincinnati, Newark, Philadelphia, Buffalo, Cleveland. Detroit, Seattle, Los Angeles, Albany, Minneapolis, Salt Lake City, Greensboro, N. C., Zanesville, Ohio, Tampa, Fla., Baltimore, Md., Des Moines, Iowa, New Haven, Conn., Sheboygan, Wis., Kansas City, Mo.; ENGLAND: 22-23 Clerkenwell Close, London, E. C. 1. CANADA: The Trane Co., 21-23 River St., Toronto, 2; Thomas Robertson & Co.; 134 Craig St., West, Montreal, F. S. Murdoch, 310 Breadalbane, Winnipeg; A. B. Madden, 48 Sparks St., Ottawa. JAPAN: Mitsubishi Shoji Kaisha, Ltd., Tokyo. CHINA: C. J. Doughty & Co., 8-9-10 Brenan Road, Shanghai.

The Trane Systems of Vapor and Vacuum Heating, Patented Heating Specialties, Trane Heat Cabinets, and Trane Automatic Electric Pumps, For All Purposes

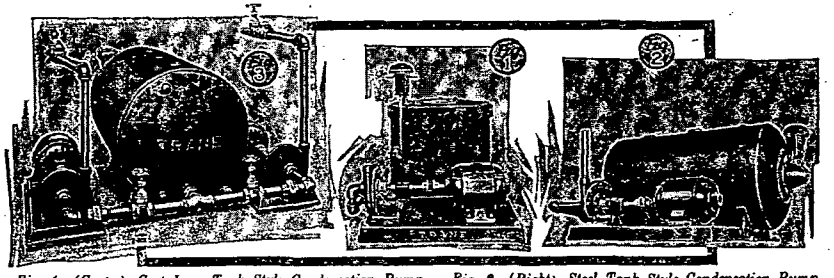


Fig. 1. (Center). Cast Iron Tank Style Condensation Pump Fig. 2. (Right) Steel Tank Style Condensation Pump Fig. 3. (Left) Duplex Type Condensation Pump

THE TRANE LINE

Trane Vacuum Pumps

Trane Vacuum Pumps are furnished in capacities ranging from 6000 sq. ft. to 100,000 sq. ft. There are at this time over three hundred and fifty (350) sizes, styles, and combinations of Trane Vacuum Pumps, divided into the following general classifications:

The Two-Motor Trane Return Line Special.
The Four-Motor Trane Duplex Special.
The Trane Standard Return Line.
The Trane Standard Duplex.
The Trane Air Line Vacuum Pump.

Trane Condensation Pumps

(Boiler Feed)

Trane Boiler Feed Pumps are furnished in capacities ranging from 4000 sq. ft. to 100,000 sq. ft. There are seventy-seven standard sizes, divided into two classifications:

Single Units. Duplex Units.

Trane Sump Pumps

(Bilge and Sewage)

Trane Sump Pumps are furnished in capacities ranging from 5 g.p.m. to 1000 g.p.m. Two classifications:

Single Units. Duplex Units.

Trane General Service Pumps

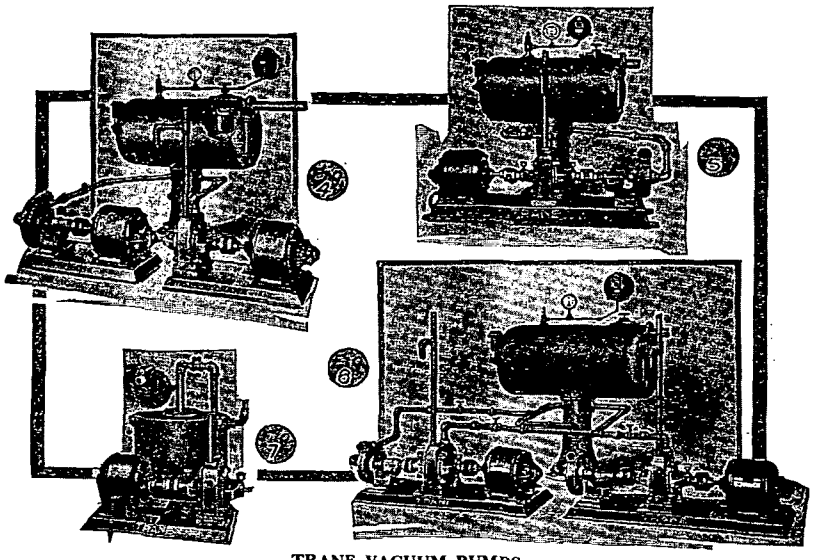
Trane General Service Pumps are the standard Trane centrifugals used with or without receiving tanks. Capacities range between 5 g.p.m. to 5000 g.p.m. against pressures ranging from 0 to 200 pounds. There are many sizes, divided into two broad classifications:

Circulating Pumps. Booster Pumps.

Special Air and Gas Pumping Apparatus

Trane Air and Gas pumps handle from 3 c.f.m. to 125 c.f.m. They are classed as

Compressors	Exhausters
Agitators	Gas Pumps
Core-Suckers	Priming Pumps



TRANE VACUUM PUMPS

Fig. 4. Two-Motor Return Line Style. Fig. 5. Single Unit Return Line. Fig. 6. Duplex Return Line. Fig. 7. Air Line

BOOSTER AND CIRCULATING PUMPS

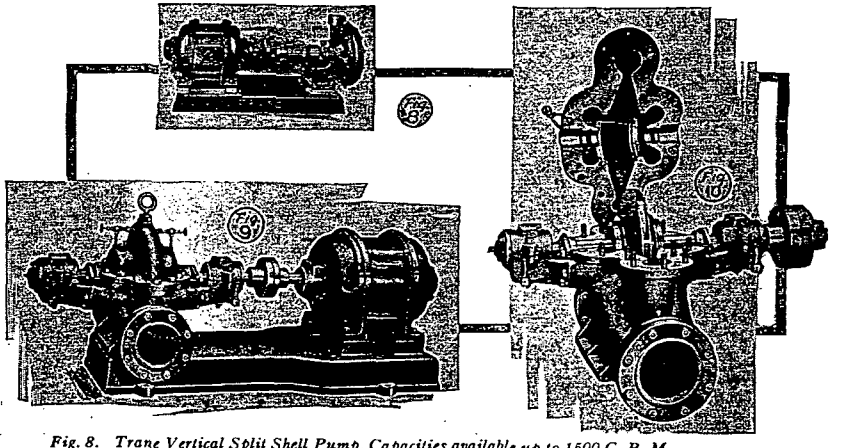


Fig. 8. Trane Vertical Split Shell Pump, Capacities available up to 1500 G. P. M.
Fig. 9. Trane Horizontal Split Shell Pump, Capacities available between 100 and 5000 G. P. M.
Fig. 10. Interior of Trane Horizontal Split Shell Pump.

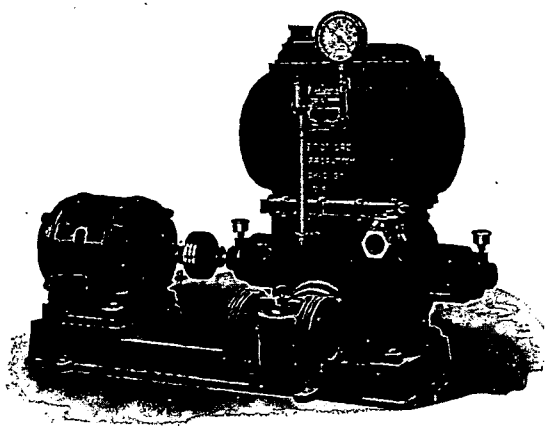
GUARANTEE

Every Trane Pump is guaranteed to deliver its rated capacity against the head or pressure for which it is sold. In addition it is guaranteed against all mechanical defects for a period of one year.

Skidmore Corporation

General Offices and Factory

1535 Dayton Street :-: :-: CHICAGO, U. S. A.



The New Type "B"

SKIDMORE HYDRO TURBINE VACUUM AND BOILER FEED PUMP

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 vacuum control or automatic float control or both.

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	Gal. of Water per min.	Motor H. P. 10 lb.	Motor H. P. 20 lb.	Size of Companion Flanges for Returns	Size of Discharge to Boiler	Approx. Floor Space	Shipping Weight lb.
0	5,000	8	¾	1	1½″	1″	18″x34″	500
1	8,000	11	1	1½	2″	1¼″	18″x46″	600
2	16,000	22	1½	2	2″	1¼″	18″x48″	700
3	26,000	35	2	3	2½″	1½″	18″x48″	775
4	40,000	60	3	5	2½″	2″	18″x52″	800
5	60,000	90	5	7½	3″	2″	20″x54″	1200
6	100,000	150	10	15	4″	2½″	20″x60″	1400

R. P. M. 1800 for all sizes.
Above weights are for continuous service, add 100 lb. for automatic control.

WORTHINGTON PUMP AND MACHINERY CORPORATION

113 BROADWAY, NEW YORK CITY

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Steam Pumps—Centrifugal Pumps—Power Pumps—Deep-well Pumps—Water Meters—Compressors—Feedwater Heaters—Automatic Feed Pumps and Receivers—Steam Heating Vacuum Pumps

WORTHINGTON

Manufacturing all types of pumps and air compressors used in the building trade, Worthington engineers hold no brief for any particular kind. Let them assist you in specifying the correct machinery for the purpose. The Worthington Line includes:

Steam Pumps

Simplex and duplex types; simple, compound and triple expansion; condensing and non-condensing; in all sizes and designs to meet every service requirement.

Centrifugal Pumps

Open or closed impeller, volute and multi-stage pumps, in all sizes and capacities for all heads.

Power Pumps

Single-cylinder, duplex and triplex; horizontal or vertical; single-acting or double-acting.

Deep-well Pumps

Single-plunger, two-plunger and three-plunger reciprocating types and "Axiflo" and "Coniflo" rotating types.

Sump Pumps

Centrifugal and "Axiflo" types.

Water Meters

Hot-water boiler-feed; cold-water meters of the disk, turbine and compound types, with a range of capacities from the smallest flow to the largest service; also oil meters.

Compressors

Air and ammonia; single-stage or two-stage, vertical and horizontal; belt driven, direct-connected motor or uniflow steam drive.

Feedwater Heaters

Open type, vertical and horizontal. Serves as feedwater heater, purifier, condensation receiver and feedwater softener all in one.

Automatic Feed Pumps and Receivers

For returning condensate from heating coils.

Steam Heating Vacuum Pumps

Both steam and power driven.

7583-10

YOUNG PUMP COMPANY

Dunham Building—450 East Ohio Street, CHICAGO, ILLINOIS

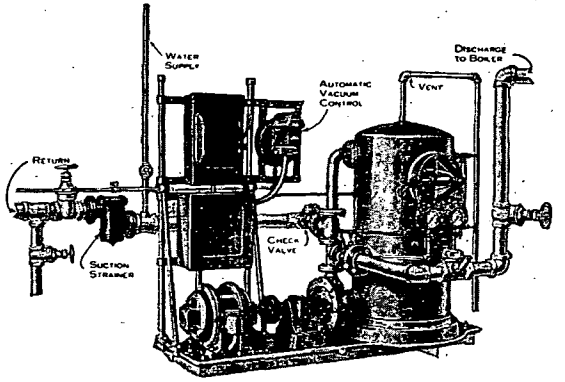
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MICHIGAN CITY, INDIANA

Agencies in All Principal Cities in U. S.

Canadian Office and Factory
C. A. DUNHAM Co., Ltd., 1523-41 Davenport Road, Toronto, 4, Ontario

THE YOUNG CENTRIFUGAL VACUUM AND BOILER FEED PUMP

Patented December 10, 1918



The Young Pump is a reliable Vacuum System pump for handling both gases and liquids efficiently.

The units are completely assembled (including electrical equipment) at the factory and tested before shipment. They are ready to run when the feed wiring is connected to the unit.

The unit consists of a Centrifugal Pump, bronze fitted, of enclosed impeller and high efficiency type, an approved make of motor and electrical equipment, mounted with a heavy welded tank on a substantial cast iron base.

The motor used is of 40° rating, of more than ample power for the maximum load that will come on the unit. A safety factor insuring freedom from motor trouble.

All Standard Units are built to discharge against a pressure of 20 pounds at the pump, except the Standard Unit V0A which is built to discharge against 18 pounds pressure at the pump. Special pumps can be furnished to discharge against 35 pounds pressure at the pump.

Both the standard and special units are furnished for either continuous or automatic control operation.

TABLE OF CAPACITIES

Size	Sq. Ft. of Direct Radiation	Horsepower of Motor	Normal Power Load	Water Capacity G. P. M.	Air Capacity Cu. Ft.	Size of Suction	Size of Discharge	*Approx. Shipping Weight, lbs.
V0A	5,000	¾	.6	8	4.5	1¼	1¼	750
V1A	8,000	1	.8	12	6.0	1½	1½	900
V2A	16,000	1½	1.3	25	9.8	1½	2	950
V3A	26,000	2	1.8	40	16.0	2	2½	1,100
V4A	40,000	3	2.7	70	20.0	2½	3	1,200
V5A	65,000	5	4.1	100	32.0	3	3	1,250
V6A	100,000	7½	6.8	160	50.0	5	3½	1,670

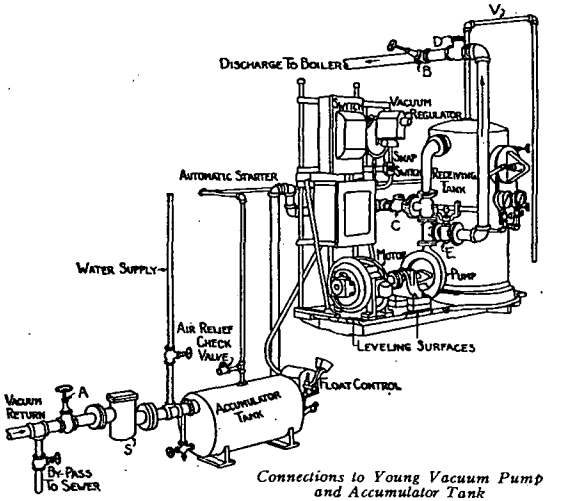
*Crated F.O.B. Michigan City, Indiana.

The capacity rating in square feet of equivalent direct radiation given in the table is for a properly laid out and equipped vacuum system that is tight. The air capacities are ample and standardized to produce under these conditions 10 inches of vacuum with reasonably tight vacuum traps, and temperature of returns not to exceed 180 deg. Fahr.

The principle of the vacuum producing element is the oldest and most efficient in practice—that of the ejector. Whenever the pump is in operation, water is supplied under pressure to the ejector nozzle, which causes the ejector to pull a strong suction on the return line of the heating system. This suction produced by the ejector is particularly positive.

Where the returns come back at a low level an accumulator tank is recommended in preference to an ordinary lift connection, with all the returns gravitating into it.

YOUNG ACCUMULATOR TANK

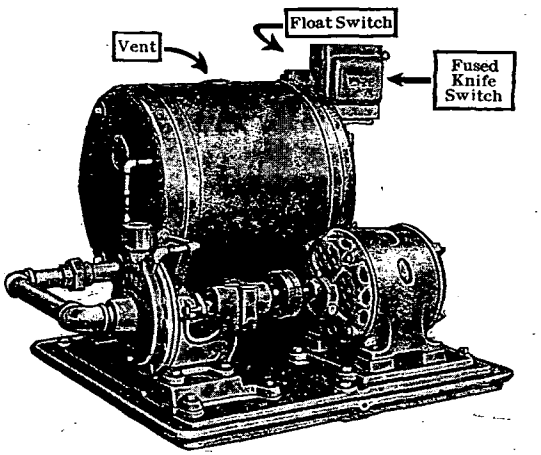


Connections to Young Vacuum Pump and Accumulator Tank

The accumulator tank is equipped with a float switch control wired to the other control. Air and the water of condensation flow into the accumulator tank from which they are pumped by the pump unit. Should the accumulator tank fill with water, the float control will function whether or not there is vacuum on the return line of system. The snap switch between the vacuum regulator and starter can be used thus operating the pump as a condensation pump and receiver. This insures water being returned to the boiler at all times.

This accumulator tank equipment is particularly valuable where blast or other radiation is at a low level which must always be drained when vacuum is not required on other parts of the system.

YOUNG CONDENSATION PUMP AND RECEIVER



A Complete and Assembled Unit Ready for Piping and Wiring Connections

Yeomans Brothers Company

(ESTABLISHED IN 1898)

1440 Dayton Street - CHICAGO, ILL.

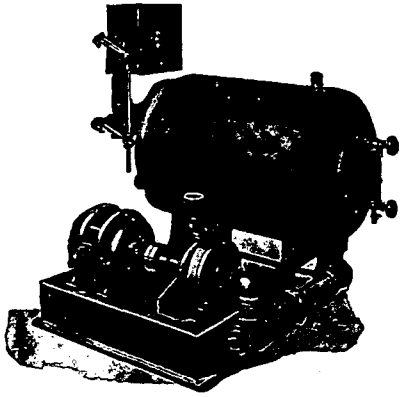
Manufacturers of a Complete Line of Pumps

PRODUCTS

Shone Pneumatic Sewage Ejectors
Yeomans Centrifugal Sewage Ejectors
Sewage Pumping Plants for municipalities
Bilge or Sump Pumps, Electric or Steam Driven, Single or Duplex
Emergency Flood Pumps
Condensation Return Pumps
Centrifugal Pumps for all purposes

Yeomans automatic electric Condensation Return Pumps are designed for returning condensate from gravity heating systems to boilers where the return lines are too low to drain by gravity. They are built in horizontal type, suitable for return lines above basement floor level, and vertical type for return lines close to or below floor level.

The type HCC horizontal pump includes a heavy cast iron receiver mounted on same cast iron base with pump and motor and equipped with carbon butt contact enclosed automatic float switch, enclosed knife switch and protective device, all built to meet the most exacting demands and for service where dependability is of vital importance.



HCC Condensation Pump and Cast Iron Receiver



Type V

The type HCS horizontal machine, though compact, durable and economical in operation, is of lighter construction, being equipped with steel receiver, light type enclosed float switch and without knife switch.

The type V vertical unit is similar in construction to the Yeomans Electric Bilge Pump, being equipped with cast iron receiver or basin, cast iron cover, vertical direct connected motor and enclosed automatic control.

Special pumps for larger capacities and higher pressures can be furnished on order.

STANDARD SIZES—TYPE HCC

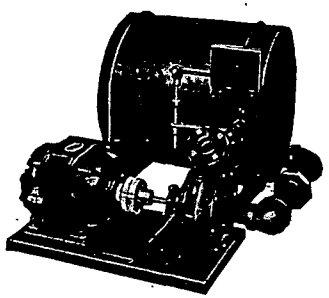
Pump No.	Max. Sq. Ft. Direct Radiation	Gals. per Min.	Size of Receiver	H. P. of Motor		Approximate Shipping Weight
				10 lbs.	20 lbs.	
1	1,000	5	20x30	½	1	1,000
2	3,000	10	20x30	½	1	1,100
3	6,000	15	20x30	¾	1½	1,200
4	10,000	20	20x40	¾	1½	1,400
5	15,000	30	20x40	1	2	1,500
6	30,000	60	20x40	2	3	1,600

STANDARD SIZES—TYPE V

Pump No.	Max. Sq. Ft. Direct Radiation	Gals. per Min.	Size of Receiver	H. P. of Motor		Approximate Shipping Weight
				10 lbs.	20 lbs.	
1	1,000	5	24x48	½	1	1,500
2	3,000	10	24x48	½	1	1,550
3	6,000	15	24x48	¾	1½	1,600
4	10,000	20	24x48	¾	1½	1,650
5	15,000	30	24x48	1	2	1,750
6	30,000	60	24x48	2	3	1,850

Standard Sizes—Type H. C. S.

Pump No.	Sq. Ft. Direct Radiation	Size of Receiver	H. P. Motor	
			10 lbs.	20 lbs.
2	1000/3000	18"x20"	½	¾
3	4000/6000	18"x20"	½	¾
4	7000/10000	18"x24"	½	1
5	11000/15000	18"x24"	½	1
6	16000/30000	18"x24"	¾	1½
7	31000/45000	18"x30"	1	1½
8	46000/60000	18"x30"	1½	2



Type H. C. S.

The AEROLOGIST

Sine timore aut beneficio

Published Monthly at 64 W. Randolph Street, CHICAGO

DR. E. V. HILL, Editor

THE policy of the AEROLOGIST is to foster and promote a better understanding of the real fundamentals of ventilation and *to broaden the demand for the same;* to discourage the belief that ventilation is merely a matter of opening a window; to encourage careful consideration of the quality of the air as well as the quantity, with proper control over temperature, humidity, etc.

Its interest includes and is circumscribed by more economical and more efficient methods, air cleansing devices, humidification; dehumidification, humidity control, temperature control, air moving machines, air heating or cooling—in fact any of the devices necessary for conditioning air either for physiological or industrial purposes.

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The Heating and Ventilating Magazine

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1123 Broadway

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105 So. Dearborn St.

A Monthly Journal of Engineering Progress

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Heating and Ventilation is a specialized branch of engineering. It comprises consulting engineers who design the heating, ventilating, and air conditioning systems for schools, hospitals, hotels, office buildings, department stores, apartment houses, institutions and industrial plants. They specify or buy the apparatus and material and supervise the installation—*the most direct sales contact for manufacturers of such apparatus and material.*

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Board of Education Engineers.

Superintendents of Central Station Heating Plants and the big Heating and Piping Contractors throughout the United States.

Calibre and buying power are outstanding characteristics of the readers of *The Heating and Ventilating Magazine.* Their services are required only where high grade material and workmanship are a larger consideration with the architect and owner than mere price.

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The reader interest is keen and genuine. It is maintained by a well-rounded editorial program devoted to progress in the heating and ventilating field. The program includes and provides for the publication of original articles by recognized engineers describing the latest ideas successfully applied in heating, ventilating and air conditioning. Another important feature is the monthly publication of four pages of standard Heating and Ventilating data for use by Engineers in the design and layout of heating and ventilating systems.

Rates

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Twelve consecutive
insertions..... 100.00 per page

Over 180 manufacturers of heating and ventilating apparatus and appliances are using the advertising columns of *The Heating and Ventilating Magazine* every month in the year.

Member A. B. C.

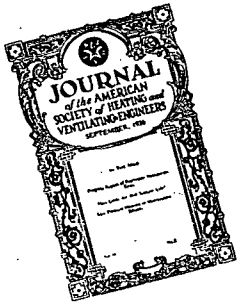
THE DIRECT ROUTE
to the Specifier and Buyer of Heating and Ventilating Equipment

Member A. B. P.

Subscription Price $2.00 per year.

JOURNAL
OF AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS

29 West 39th Street NEW YORK, N. Y.



THE JOURNAL

of the AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS is the official organ of the Society, whose purpose is to promote the art of heating and ventilating, to act as a medium for the exchange of engineering experience, to standardize the industry by means of codes of design and testing, and to conduct research investigations for ascertaining the uncertain factors in the art.

The JOURNAL appearing monthly, is read by 3,000 consulting engineers, architects and contractors actively engaged in heating and ventilating work. It gives them technical articles on important subjects, makes a permanent record of discoveries, experiments and other developments in the industry and thereby keeps them in constant touch with the best thought in the profession. The Society's meetings, news of the local Chapter events, and other happenings in the heating and ventilating field are also reported.

An exclusive service to JOURNAL readers is the presentation of the reports, made by the Society's Research Laboratory, reference data which is invaluable to the engineer, contractor and manufacturer in his daily work.

The JOURNAL offers manufacturers the opportunity of placing their equipment before a large group of discriminating buyers at a minimum cost. The fact that it is devoted exclusively to heating and ventilating engineering in all its branches makes it a most desirable advertising medium and especially so because of its class circulation. In addition to its proven merit as an advertising medium, its use by manufacturers indicates their desire to co-operate with the Society in advancing the interest of heating and ventilating.

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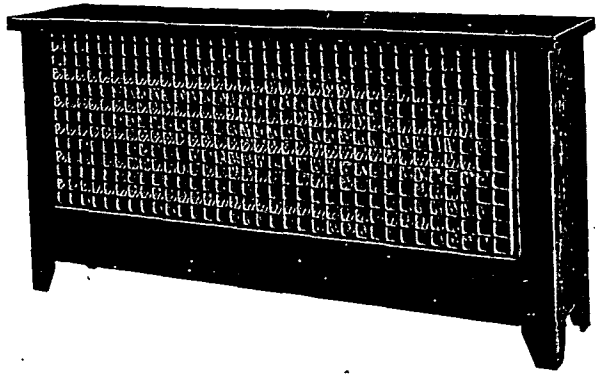
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The Bridgeport Rolling Mills, Inc.

Bridgeport, Conn.

SAGE CABINET RADIATORS

Copper Radiation for Direct Heating



Reduces Boiler Capacity Required | **Saves in Fuel Cost** | **Heats Very Quickly** | **More Uniform Room Temperatures** | **Ideal For Concealed Radiation** | **Heats from Roomside Only** | **Cannot Soil Wall or Decorations**

RADIATORS 18 Inches High

The **Sage Radiator** is a revolutionary development in radiator construction in recognition of an insistant demand for improvement in direct radiation. Entirely of pure copper and brass construction, the **Sage** is of the small tube and fin type extended surface. The tubes used are seamless drawn $\frac{5}{16}$ inches diameter of pure copper and as many as 210 are used per radiator. Fins are of high brass 2¼ inches long and ⅞ inches wide spaced three to 1 inch of element length forming channels of air passage. Headers are of cast bronze without baffles. Core plates are of high brass. Steam is in contact only with pure seamless copper tubes. The **Sage** will not become air bound. Finished in DULL MATT Brass.

Heating Surface: More than 2 sq. ft. of heating surface to each square foot of rated capacity.

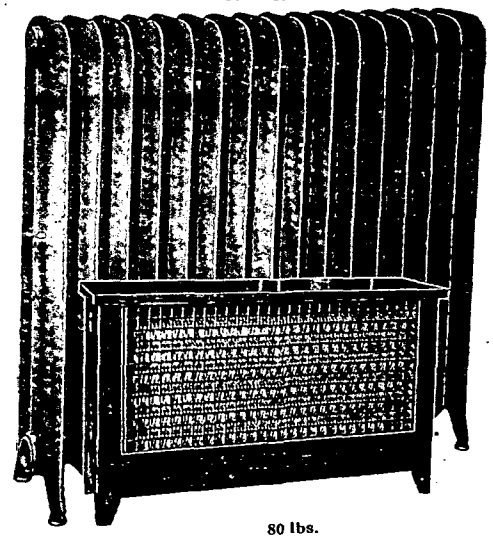
Ratings; Based on condensation—**under-rated** and **not over-rated.** Usual estimating rules can be applied.

CABINETS 20 Inches High

Sage Radiator Cabinets must be seen to fully appreciate the unusual high quality of the natural wood grained finishes. No greater care could be taken in the finishing of any piece of furniture. **Sage Cabinets** will enhance the appearance of any room no matter how well furnished. Optional finishes are American Walnut, Red or Brown Mahogany, French Ivory, White, or may be had unfinished with prime coat for finishing by interior decorator. First coats are baked enamel. Finishing coats are in highly polished lacquer. Graining is done by a new photographic process from wood selected for beauty of grain and faithful reproduction is assured.

Built from best grade furniture steel. All joints electrically welded. Hinged cover fully insulated and front grill removable. Cabinets are practically indestructible.

560 lbs.



80 lbs.

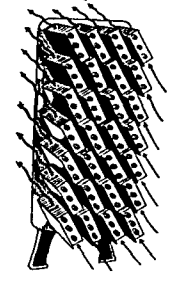
RADIATORS OF EQUAL CAPACITY

Sage Radiators weigh only 1 pound per foot, very greatly reducing freight, trucking, storage and installation costs. Any ordinary size **Sage Radiator** can be easily handled and connected by one man. Size permits use of one **Sage** where two radiators of the conventional types are necessary.

Concealing Sage Radiation is most practical and inexpensive. Used covered or concealed as under window seats, etc., without loss of heating efficiency.

The accompanying illustrations demonstrate how the **Sage Radiator** is designed to create and facilitate the essential air movements of radiation—controlling and directing such air movements through the radiator, over all radiating surfaces in channels formed by fins and giving heated air proper direction of discharge—**an angle of 60% into the room and from a height of not more than 18"** which has been found to be the most effective for efficient heating.

As steam enters the header of very small capacity it is immediately distributed to all parts of the radiator by the tubes, small enough to compel use of the entire tubular capacity, producing an effective pressure, evenly maintained and still ample in size for all volumes of steam or water in circulation.



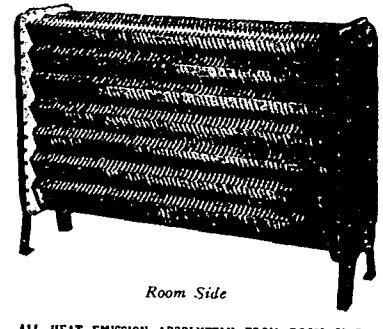
Entrance of cold air is from the bottom and back or wall side. **Sage** construction automatically creates such air currents.

A thermometer within one inch of the radiator, in back at top, will register not more than 2 deg. higher than temperature at opposite side or center of room. Produces room temperatures that are remarkably uniform.

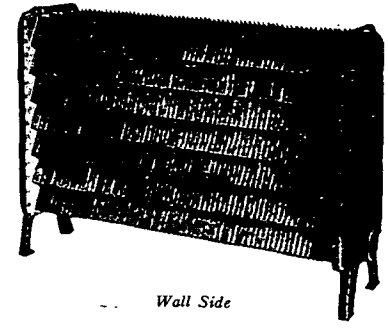
SAGE is the pioneer in copper radiation for Direct Heating.

Many **Sage Cabinet Radiators** have given satisfaction in service for four years. Heretofore in small production, **Sage** is now available in large quantities and very reasonably priced.

MADE ENTIRELY OF COPPER AND BRASS



Room Side



Wall Side

ALL HEAT EMISSION ABSOLUTELY FROM ROOM SIDE ONLY—AND ALL HEAT "CONVECTED" HEAT OF LOW TEMPERATURE

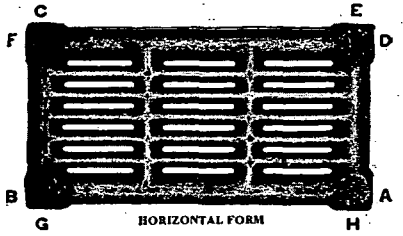
SAGE Booklet Upon Request

Fowler & Wolfe Mfg. Co.

Originators of Wall Radiators

Philadelphia, Pa.

THIRTY YEARS SERVICE WALL RADIATORS EXCLUSIVELY



(A)

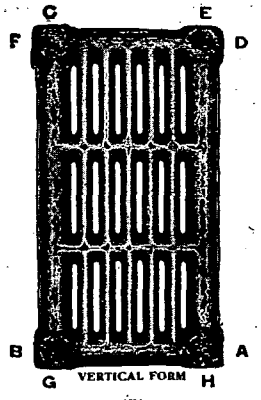
ALL sizes are made in Vertical and Horizontal forms and all in plain pattern. Bay window wall radiators may be had to meet any angle or curve of radius of not less than 6 feet. Test pressure, water, regular—100 lb. Special up to 400 lb.

Made in Six Sizes

10 sq. ft. section—24 x 13¼ x 3⅝ inches.
9 sq. ft. section—24 x 13 x 3¼ inches.
7 sq. ft. section—24 x 12½ x 3 inches.
6 sq. ft. section—21 x 12½ x 3 inches.
5 sq. ft. section—17 x 12½ x 3 inches.
3¾ sq. ft. section—17 x 9½ x 3 inches.

How to Order

First.—State number of Radiators and number of Sections in each. **Second.**—State size of Sections, whether 10 ft., 9 ft., 7 ft., 6 ft., 5 ft., or 3¾ ft. **Third.**—State whether vertical (B) or horizontal (A). (See illustrations.) **Fourth.**—State how many Sections long and how many high. **Fifth.**—State whether for Steam or Water and if Steam whether one or two pipe. Indicate location of tappings by letter (see illustration above). **Sixth.**—State style of Bracket or Support.



(B)

RIGHT AND LEFT THREADED NIPPLE CONSTRUCTION

Dixie Metal Products Co.

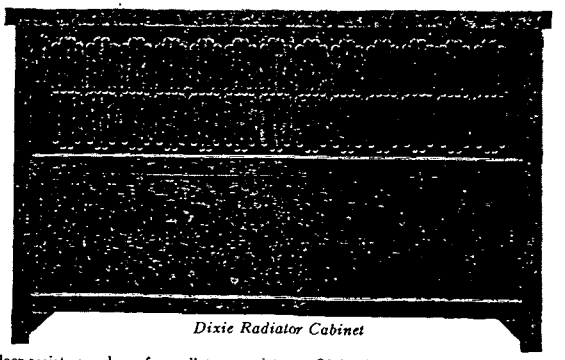
Manufacturers of SHEET METAL SPECIALTIES

Sales Offices in Principal Cities

Main Office and Factory: BIRMINGHAM, ALA.

DIXIE RADIATOR CABINETS and SHIELDS for steam and hot water radiators are designed to give the full heating efficiency of the radiator and supply an atmosphere, heated and humidified to the proper degree for comfort. Their artistic finish in twenty-one colors, their sturdy construction, high efficiency and utility completely meet the requirements of the architect, engineer, physician and housewife.

DIXIE RADIATOR CABINETS are made of high grade furniture steel with heavy insulated top and back, solid ends and openings at bottom and front to produce the proper circulation of air. A solid copper humidifying attachment is placed directly beneath the hinged cover and supplies the desired degree of moisture and thereby makes the heating plant more effective. DIXIE CABINETS prevent injury to walls, furniture, fabrics, etc., enhance the appearance of any room and fit any size or style of radiator.



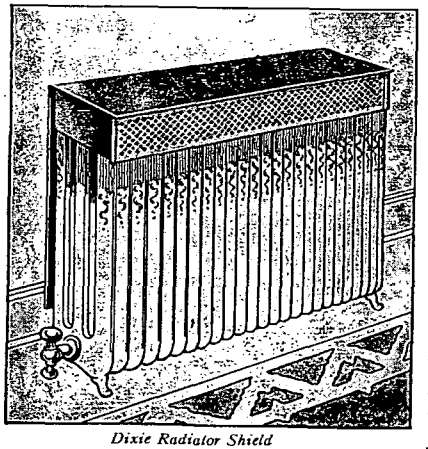
Dixie Radiator Cabinet

DIXIE RADIATOR SHIELDS are designed primarily to prevent drafts from blowing upward and injuring draperies, woodwork and walls. They are built in any size to fit all radiators and in a finish to harmonize with any decorative treatment either with full length back to floor or extending to wall.

DIXIE SHIELDS are also made for wall-hung radiators. They fit snugly and when in place make a rigid seat with low radiators or a convenient shelf on high radiators.

There is a DIXIE CABINET for use with warm air furnace installations. They are made in two styles, one for floor registers and one for wall type registers. Of furniture steel are provided with a copper vapor pan to humidify the air, protect the health of the occupants of a house and prolong the life and beauty of the furnishings.

DIXIE RADIATOR CABINETS and SHIELDS are being used with great satisfaction in homes, schools, hospitals, apartment houses, hotels, office buildings and other places where protection of health and decorations, economy of fuel and effective heating are desired. DIXIE CABINETS are priced reasonably and have no maintenance cost.



Dixie Radiator Shield

HUMIDITY TEST ON DIXIE RADIATOR CABINETS

TEST No. 1 — Pans Dry							
Time	Dry Bulb Deg. Fahr.	Wet Bulb Deg. Fahr.	Per Cent Humidity	Time	Dry Bulb Deg. Fahr.	Wet Bulb Deg. Fahr.	Per Cent Humidity
8.15 A.M.	67	55	45	9.00 A.M.	71	56	37
8.30 A.M.	70	57	44	9.40 A.M.	72	57	38
Pans Filled							
10.35 A.M.	70	56	40	12.35 P.M.	62	53	54
11.00 A.M.	69	56	43	1.10 P.M.	62	52	50
11.30 A.M.	69	56	43	1.30 P.M.	63	53	50
12.00 M.	66	55	48	6.15 P.M.	72	59	45
TEST No. 2 — Pans Dry							
10.00 A.M.	70	62	33	11.00 A.M.	74	58	36
Pans Filled							
2.00 P.M.	75	62	47	4.00 P.M.	73	61	50
3.00 P.M.	76	63	48	5.00 P.M.	74	62	47

LIST PRICE ON DIXIE RADIATOR CABINETS AND SHIELDS

Length of Unit	18" and less	19 to 24	25 to 30	31 to 35	36 to 41	42 to 47	48 to 53	54 to 60	61 to 67	68 to 75	76 to 83	84 to 92	93 to 104	105 to 118	119 to 134
Cabinets 36" high and less	$31	$34	$38	$42	$46	$50	$55	$60	$65	$71	$77	$83	$91	$101	$115
Cabinets 38" high and higher	34	38	42	46	50	55	60	65	71	77	83	91	101	115	130
Shield Price with back to wall. Solid color	8	10	12	14	16	18	20	22	24	26	28	30	34	37	40

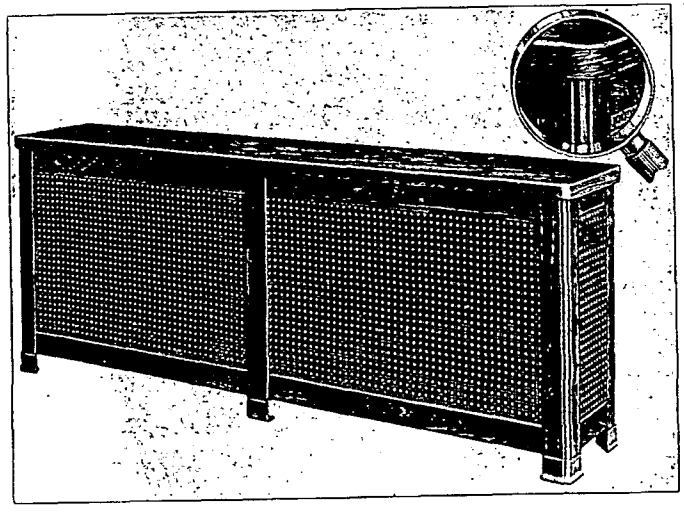
Prices on Cabinets includes all crating and boxing. F. O. B., Birmingham.

Art Metal Radiator Cover Company

General Offices and Factory
1732 N. Kolmar Avenue
Chicago, Ill.

Eastern Division
1520 Broadway, New York
New York

Representatives in All Principal Cities



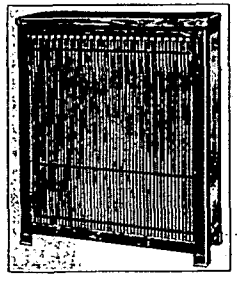
Trico De Luxe Cane Type Grille. (Note exclusive round corner top and leg design.)

PRODUCTS.—Exclusive manufacturer of TRICO Humidifying Radiator Covers and Shields—also Grille Fronts for recessed radiators, and Tricolator Warm Air Heat Cabinets.

TRICO Humidifying Covers are installed to keep walls clean, transform unsightly radiators into attractive pieces of furniture, humidify the air, and save fuel.

TYPES.—Standard and Grille. Grille in two designs, Rod and Cane. The top, humidifying water pan and back shields are the same on all types.

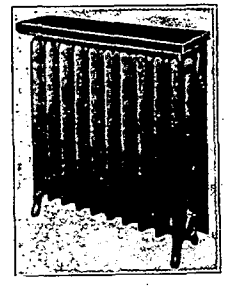
"STANDARD" TYPE COVERS.—Top is made of 14-gauge furniture steel with water filling door, finished with six coats of baked enamel, to match any sample submitted with order. Humidifying water pan and back shield is of 24-gauge. Front and ends of radiator exposed.



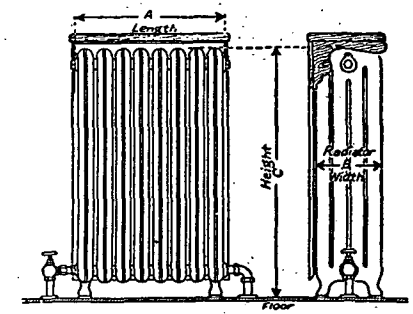
Rod Grille

LEFT—**Trico** De Luxe Rod Type Grille

RIGHT—**Trico** De Luxe Standard Cover

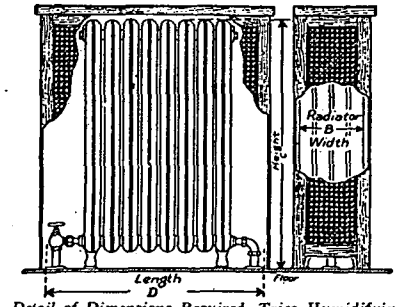


Standard Cover



Detail of Dimensions Required, Trico Humidifying Radiator Shield (Standard)

A—length, *B*—width, and *C*—height. State dimensions in inches. In measuring length do not include nut (bushings) if any.

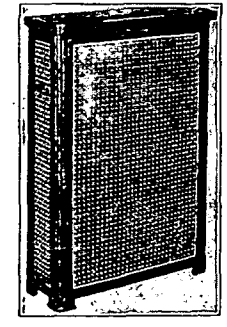


Detail of Dimensions Required, Trico Humidifying Radiator Cover (Rod or Cane)

D—length, *B*—width, and *C*—height. State dimensions in inches. Give control valves upper or lower, right or left.

Indicate type of grille as follows: *C*—cane. *R*—square rod.

"ROD GRILLE" TYPE COVERS.—Top is of 14-gauge and frame or border 16-gauge furniture steel with water filling door, finished with six coats of baked enamel to match sample furnished with order. Top, back shield and humidifying water pan same as "Standard" Type. Front and ends of radiator enclosed with Grille of quarter-inch channel rods, separated by quarter-inch ornaments. All joints carefully spot welded, not soldered.



Tricolator (Wall Type)

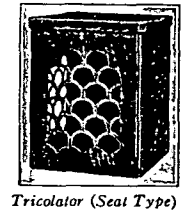
"CANE GRILLE" TYPE COVERS.—Top is 14-gauge and frame or border 16-gauge furniture steel with water filling door finished with six coats of baked enamel to match sample furnished with order. Top, back shield and humidifying water pan same as "Standard" Type. Front and ends of radiator enclosed with perforated steel imitation cane.

SPECIAL INSTALLATIONS.—Regular TRICO Covers rest 2¼ inches above the top of the radiator, unless otherwise specified. Special covers can be made where there is less than 2¼ inch clearance. A ¼-inch clearance behind the radiator is sufficient to make installation. For radiators partly recessed, an offset can be made in the back so as to throw the top forward. Curved and angle shaped radiators can be covered with either Standard or Grille types.

SPECIFICATION DATA.—Write for **Trico** File Folder with engineering data for specifications. Our local representative will be glad to call and show models, metal finish samples, give estimates etc., at your request.

TRICOLATOR FURNACE HEAT CABINETS.—Made in two types—Wall and Seat. Both types are finished in the following standard finishes: Walnut, Mahogany, Oak, Ivory, White and Prime Coat.

"WALL" TYPE TRICOLATOR FURNACE HEAT CABINET.—Top is of 16-gauge furniture steel with water filling door. Grille front and ends of 20-gauge furniture steel in imitation cane pattern. Water pan is of 24 gauge galvanized iron. Adjustable damper for wall opening made to fit all sizes of outlets. Convenient damper adjustment is arranged on side near top.



Tricolator (Seat Type)

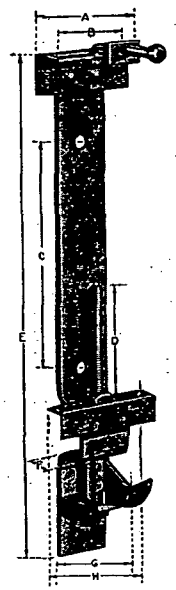
"SEAT" TYPE TRICOLATOR FURNACE HEAT CABINET.—Top is of 16-gauge furniture steel with water filling door. Grilled front and ends of 18-gauge furniture steel in both imitation cane and scroll design furnished to suit all sizes of warm air and cold air openings.

Wall Type and Seat Type Tricolator Heat Cabinets are also built for return of cold air on pipeless systems, with a boot for warm or cold air furnace connections.

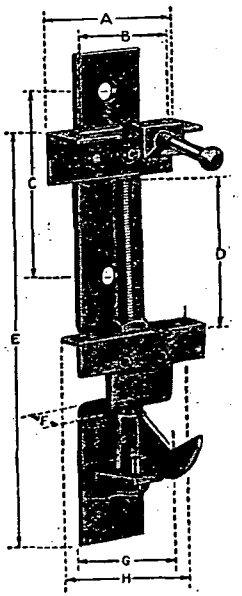
The Modern Manufacturing Company

Manufacturers of Specialties
For the Steam and Hot Water Trade

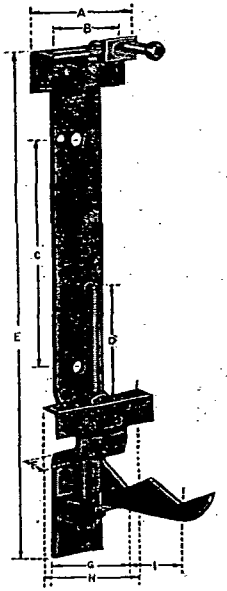
4734 Hough Avenue **CLEVELAND, OHIO**



No. 1 Wall Type
Patented
Supports 7′ and 9′ Vertical Wall Radiation



No. 2 Wall Type
Patented
Supports 5′, 7′ and 9′ Horizontal, and 5′ Vertical Wall Radiation.



Double Row Type
Patented

Same measurements as No. 1 and 2

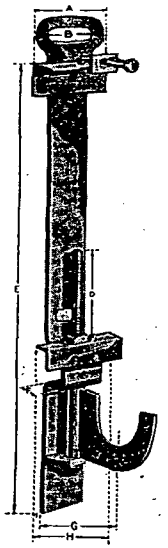
Measurements:

A—4″
B—3″ (Tie Bolt Adjustment)
C—8¼″
D—2″ (Vertical Adjustment)
E—18½″
F—1¾″ (Wall to Radiator)
G—3¼″ (Wall to Center of Shoe)
H—4″

Measurements:

A—4″
B—3″ (Tie Bolt Adjustment)
C—5¼″
D—2″ (Vertical Adjustment)
E—13¼″
F—1¾″ (Wall to Radiator)
G—3¼″ (Wall to Center of Shoe)
H—4″

Modern All-steel Adjustable Radiator Brackets are strong, simple and economical. Brackets need not be disturbed after anchoring to the wall.
Tie Bolt Adjustment is made by moving Tie Bolt along slot in top angle.
Vertical Adjustment is made by turning Bolt Head at bottom of shoe.
We also make similar Brackets—which hold radiation—2½ inches from wall.

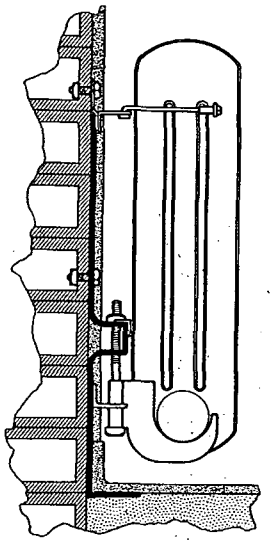


Column Type Patented

A—3½″
B—2½″ (Lateral Adjustment)
D—2″ (Vertical Adjustment)
F—1¾″ (Wall to Radiator)

Only one Anchor Bolt required for ordinary installations.

Lower Anchor Slot used only for special installations.

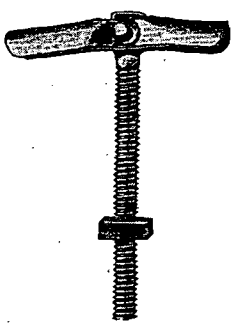


This Bracket is desirable for installations in hospitals or buildings with finished walls and tiled floors.

Made for all types of Column Radiation.

This type does not provide for Baseboard Adjustment.

Similar Bracket is made that holds radiation 2½ inches from wall and provides for Baseboard Adjustment.



Toggle Bolt
Style No. 1
Made up to ½″ x 6″

EXTENSION PIPE CLAMP

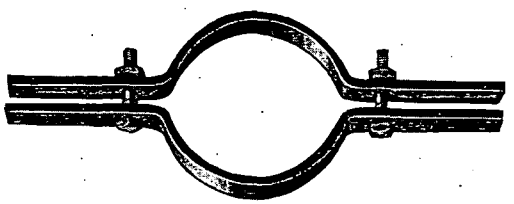


Fig. 500
Made in All Sizes

Write for Catalogue showing our line of HEATING ACCESSORIES

Healy-Ruff Company

St. Paul, Minn.

AGENTS IN THE FOLLOWING CITIES
UNITED STATES

ATLANTA, GA., CHARLOTTE, N. C., RICHMOND, VA., PITTSBURGH, PA., INDIANAPOLIS, IND., SAN FRANCISCO, CALIF., SEATTLE, WASH., SPOKANE, WASH., NEW YORK CITY, DENVER, COLO., DES MOINES, IOWA., DETROIT, MICH., AMSTERDAM, N. Y., CHICAGO, ILL., CINCINNATI, OHIO, TOLEDO, OHIO, ST. LOUIS, MO., BIRMINGHAM, ALA., KANSAS CITY, MO., OMAHA, NEB., WICHITA, KAN., DALLAS, TEXAS, MILWAUKEE, WIS., BUFFALO, N. Y., DAVENPORT, IOWA, PHILADELPHIA, PA., BOSTON, MASS., CLEVELAND, OHIO, COLUMBUS, OHIO, LOS ANGELES, CALIF., BALTIMORE, MD., WASHINGTON, D. C., MEMPHIS, TENN., CHATTANOOGA, TENN., IRONWOOD, MICH., NASHVILLE, TENN., BUTTE, MONT.

CANADA

TORONTO, VANCOUVER, HALIFAX, MONTREAL, WINNIPEG, OTTAWA, CALGARY

Manufacturers of E-Z Radiator Hangers Write 781 Hampden Avenue

E-Z RADIATOR HANGERS are designed to hang all Wall and Column Radiation of any make. They have both vertical and horizontal adjustments, and are designed to anticipate the use of temperature control valves.

Only one bolt per hanger. No accurate placing of anchor bolts required. Hanger absolutely invisible, including washer at top.

Style "R", shown below, places radiator 1½ in. from wall, but is not adjustable for baseboard. Convertible, with parts No. 5 and No. 8, into Style "H", which places radiator 2½ in. from wall and provides for baseboard adjustment.

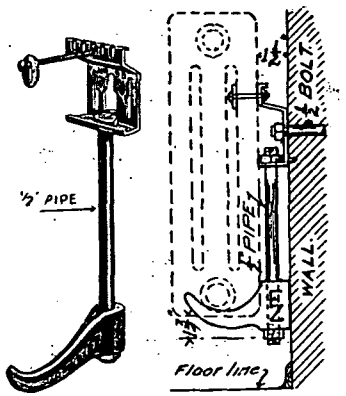
TYPICAL SPECIFICATIONS

Where Baseboards Are Used

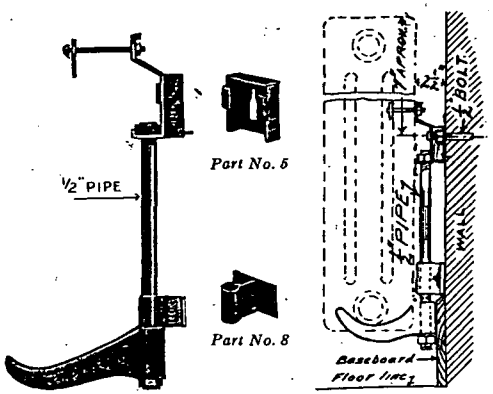
All radiation, unless otherwise noted, shall be supported on wall by means of E-Z Radiator Hangers, Style "H" as manufactured by the Healy-Ruff Co., St. Paul, Minn., or equal and approved in writing by the Architect arranged to support the radiator 2½ in. from the wall and with baseboard adjustment.

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," as manufactured by the Healy-Ruff Co., St. Paul, Minn., or equal and approved in writing by the Architect, arranged to support the radiator 1½ in. from the wall.



Style "R" Hanger, Without baseboard adjustment

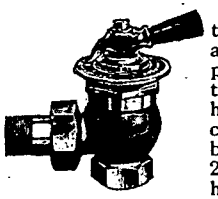


Style "H" Hanger, with baseboard adjustment

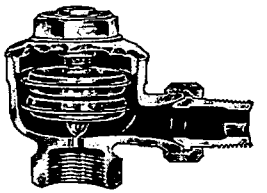
Barnes & Jones

5 Melrose Street, Boston, Mass.

Modulating Vapor and Vacuum Steam Heating Apparatus—Modulation and Thermostatic Return Valves—Condensators, Blast Traps, and Vent Traps



Barnes & Jones modulation systems, either pressure or vacuum, are applicable to every heating problem from the smallest house to the largest office building. They have many special advantages in construction and design which have been developed as a result of our 25 years of experience with steam heating problems.



Barnes & Jones Modulation Valve

Barnes & Jones modulation valve completely controls the heat of each radiator, allowing it to be heated wholly or partially, independently of every other radiator.

It can be opened in less than a full revolution of the handle, and can be forcibly closed to the seat so as to be tight under any operating condition. It does not require repacking. Has renewable disc seat.

Sizes and Models—Made in the angle type, in sizes from ¾ to 1½ in. Standard model has lever handle. Other models include:

Wheel Handle—With indicating dial.

Extension Stem—With indicating dial, for use with enclosed or concealed radiators.

Chain Operated Type—Modulation valves on radiators and coils located overhead on walls, ceilings, and in skylights can be equipped with chain extensions to permit operation from floor.

Lock Shield Model—For corridors, toilets, etc.

Barnes & Jones Thermostatic Radiator Trap

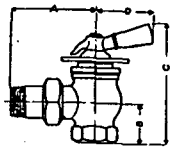
The successful operation of open return line vapor systems and vacuum systems depends on the efficiency of the radiator traps. These must be sensitive, so as to close in the presence of steam and open as soon as air or water of condensation begins to accumulate. Their action must be independent of pressure conditions.

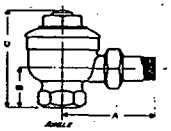
Barnes & Jones radiator trap is of the Thermostatic diaphragm type, its moving power being obtained by the expansion and contraction of a volatile liquid enclosed in a hermetically sealed diaphragm. Its double diaphragm of tempered phosphor bronze allows wide range of travel with minimum strain. Each trap is factory adjusted and tested to rigid standards.

Types and Sizes—This valve is made in ½", ¾", 1" and 1¼" sizes. The ½" and ¾" sizes are made in four types—angle, straightway, right hand corner and left hand corner patterns. The 1" and 1¼" are made in the angle pattern only. The ½" size, unless otherwise specified, is made with ¾" outlets, thus avoiding the use of all ½" pipe and reducing fittings.

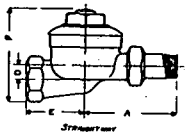
Construction Details

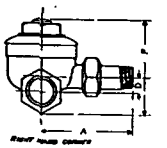
Both valves made of best grade cast composition throughout. Cover and trimmings are highly polished. Tail piece and union nut extra heavy to prevent breakage; tail piece made long for easy connection. Lugs located under threads.





Modulation Valve





Thermostatic Radiator Trap

DIMENSIONS					Capacity in square feet of cast iron radiation
Size Valve	A	B	C	D	
¾"	2¾	1¼	3½	1⅞	60
1"	3	1⅜	3⅝	1⅞	100
1¼"	3½	1½	3⅞	1⅞	180
1½"	3¾	1½	4⅛	1⅞	250

CAPACITIES			
Size Valve	Lbs. water per hour	Sq. feet C.I. Rad.	Sq. feet Coils
½"	30	125	100
¾"	80	320	240
1"	200	800	600
1½"	400	1600	1200

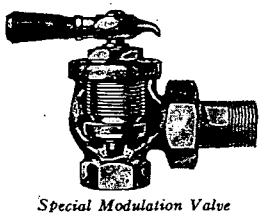
DIMENSIONS						
Size Valve	A	B	C	D	E	F
½"	3⅛	1⅛	3⅜	½	2	3⅛
¾"	3⅜	1⅛	3½	⅝	2⅛	3½
1"	3⅜	1¼	3⅜	¾	2⅜	3⅜
1¼"	4⅛	1¾	4⅛			

The Bishop & Babcock Sales Co.

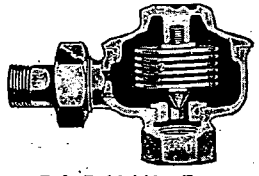
GENERAL OFFICES: 4901—4915 Hamilton Avenue, N.E., CLEVELAND, OHIO

AMSTERDAM, N. Y.....F. E. Dwyer, 447 Guy Park Ave.
BALTIMORE, MD.....Building Service Co., 404 St. Paul St.
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LYNCHBURG, VA.....Cleland Eng. Co., 208—5th St.
MINNEAPOLIS, MINN., Continental Sales Co., 924 Metropolitan Life Bldg.
NASHVILLE, TENN.....Ryan Sales Co., 922 Stahlman Bldg.
NEW YORK, N. Y., The Bishop & Babcock Sales Co., 444 Lafayette St.
OKLAHOMA CITY, OKLA., Federal Steam Specialty Co., 120-2 E. Main St.
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RICHMOND, VA.....Virginia Equipment & Supply Co.
SAN FRANCISCO, CALIF., Walter S. Leland. 532 Natoma St.
SPOKANE, WASH., R. L. Nelson, 507 Empire State Bldg.

Heating Specialties—Temperature Control—Ventilating Equipment



Special Modulation Valve



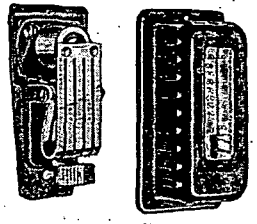
B. & B. Multiflex Trap No. 6

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—every device for the entire system can be a B. & B. product.

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.

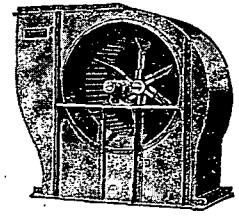
Seamless one-piece Multiflex Metal Bellows are a fundamental part of **Bishop & Babcock** Heating Specialties and Temperature Regulation. In the manufacture of these vital parts for the construction of Thermostatic Traps, Valves, and other devices **Bishop & Babcock** exercise the same care and rigid adherence to high standards that characterize all their products.

Our Engineering Data Book, pocket edition, will be mailed upon request.



All Metal Thermostat

Separate catalogues are issued on **Bishop & Babcock** Temperature Control Systems and Massachusetts Fans, Blowers and Air Washers —copies of which will be furnished upon request.



Single Width Squirrel Cage Fan

Combustion Specialties Corporation

Walter S. Timmis, past president of the AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS has written an extensive report on COMBUSTO Draft System from which the following paragraphs are quoted. (Complete report will gladly be forwarded on request.)

Manufacturers of

DRAFT **COMBUSTO** REG. U.S. PAT. OFF. SYSTEM

250 West 54th Street, New York

FOR HEATING PLANTS
Saves coal and labor, maintains even heat with less draft.

FOR POWER PLANTS
Higher evaporation per pound of coal eliminates smoke

Mr. Timmis states, "To secure the most economical results in combustion for heating it is necessary to use the proper amount of air under the fuel bed for the distillation of the gases and the correct amount of air properly diffused, preferably heated and delivered over the fire bed in order to complete the combustion by burning the distilled gases—**in brief—an efficient boiler is a gas producer having means for consuming gas produced.**"

WHAT COMBUSTO IS

To quote Mr. Timmis further, "**Combusto** is a system carefully studied, tested and developed for each individually 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."

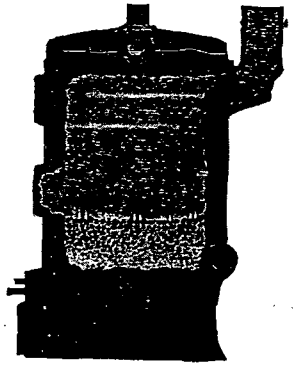
UNIQUE AND FUNDAMENTAL REQUIREMENT FOUND IN COMBUSTO

"Perhaps the most important feature of **Combusto** is the resistance to the flow of air through the apparatus itself, which is made to equal the resistance of the fuel bed, thus producing a balanced condition above and below and through the fuel bed—**a fundamental requirement for correct and economical combustion which is ignored in regular furnace and boiler design.**

WHAT COMBUSTO DOES
(See illustration of COMBUSTO equipped plant below.)

"**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."

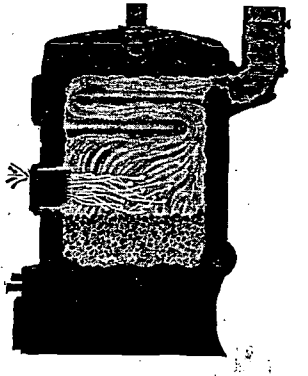


COAL WASTED (Left)

Without **Combusto**, a checked fire produces no dependable results. The gases that distill from fuel bed are a total loss. Heat can be produced only by speeding up stack draft. This is wasteful and requires frequent attention.

COAL SAVED (Right)

With **Combusto**, all gases are burned completely with Bunsen blue flame with stack draft continuously checked to minimum. Hence, amount of gas made can be regulated to amount of heat needed by simple adjustment of the ash pit damper.



SPECIFICATION: The following clause adopted since 1916 by one of the largest railways in the United States is suitable as a standard specification in connection with low pressure hot water or heating boilers or warm air plants. "Equip all boilers (warm air furnaces) with **Combusto** of size recommended by Combustion Specialties Corporation's engineers."

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.

PRICES: Prices range from $25.00 on small house-heating plants to $200.00 on largest low pressure heating boilers. Definite estimates cannot once be submitted if manufacturer's name and number of boiler is sent to us, together with size of grate and number of fire doors.

C. A. Dunham Co.

Administrative and General Offices: 450 East Ohio Street, Chicago
Factories at Marshalltown, Iowa, and Toronto, Ont., Canada

BRANCH SALES OFFICES:
Birmingham, Boston, Cheyenne, Chicago, Cincinnati, Cleveland, Dallas, Davenport, Denver, Des Moines, Detroit, El Paso, Indianapolis, Kansas City, Los Angeles, Louisville, Milwaukee, Minneapolis, New Orleans, New York, Omaha, Philadelphia, Pittsburgh, Portland (Ore.), Rochester, St. Louis, Salt Lake City, San Francisco, Seattle, Spokane, Troy, Washington.

C. A. DUNHAM CO., LTD., General Offices and Factory, Toronto, Ont.

BRANCH SALES OFFICES: Calgary, Montreal, Ottawa, Toronto, Winnipeg, Vancouver, Halifax.

FOREIGN SALES OFFICES: London, England; St. John's, Newfoundland
Distributors: Munsing & Co., Paris, France, 47 Rue Fontaine-au-roi

Manufacturers of Specialties for The Dunham Systems of Heating

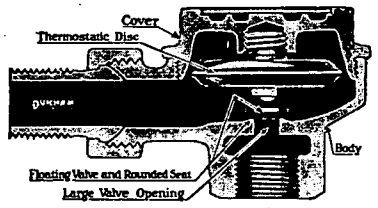
The DUNHAM HEATING SERVICE

This Service is delivered through over 60 Branch and Local Sales Offices throughout the United States and Canada. 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.

Products

Specialties for use in connection with The Dunham System of Heating, known according to its several adaptable forms as The Dunham Home Heating System; The Dunham Return System and The Dunham Vacuum 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 Pumps; Vacuum Pump Governors; Air Eliminators; Air Check; Oil Separators; Suction Strainers; Air Vents; Damper Control; Gauges.



Sectional View of No. 1 Trap

Dunham Radiator Trap

The Dunham Radiator Trap first put into service in 1903 completely revolutionized Steam Heating.

The Dunham Thermostatic Trap consists of two major parts, a body, and a cover. In the cover the operating member, the Dunham Thermostatic Disc, is securely placed. It has an exceptionally large valve opening. There are no detached loose parts in the path of flow, no sliding contacts to gum up, and no guide or pin to obstruct the valve opening or cause the valve to wear unevenly. The position and design of the valve is such that it is self-cleaning, and the closing of the trap will be tight even where the water is high in incrustants which deposit on the interior of the piping. The action of the disc is positive and the floating valve seats squarely, like a globe valve. The body is standardized, also the cover and disc, giving the further advantage of interchangeable parts.

The 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 one-half in. radiator traps.

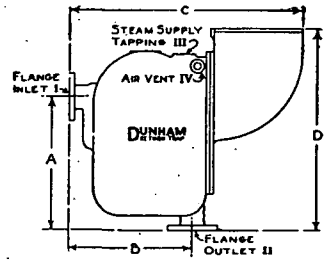
The working part of the Trap, the Thermostatic Disc, is fully exposed to the actual conditions within the radiator and it, therefore, responds instantly to any change taking place therein, preventing waste of unused steam, backing up of water and air binding.

It is made in five sizes and for varying pressures not to exceed 10 lb. gage.

These traps are used principally in steam heating work where they are attached to all forms and types of radiation, and to steam piping and risers for dripping purposes. The Nos. 1 and 2 Traps are used almost exclusively on radiators. The No. 3 Trap is used for large radiators, for medium size pipecoils, and is particularly adaptable for dripping risers and short runs of steam piping. The Nos. 4 and 5 Traps are used where traps of large capacity are required on large pipe coils, for dripping main steam risers, and steam mains.

DUNHAM RETURN TRAP

Used to separate the air and water discharged into the dry return piping by the Radiator Traps, to release the air, and to automatically return the water to the boiler. For use on installations where the boiler steam pressure does not exceed 10 lb. gage.

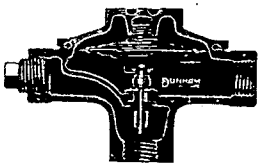


Size No.	Capacity Sq. Ft. Div. Radiation	Size of Connections, inches				Dimensions, inches				Width Over All
		I	II	III	IV	A	B	C	D	
9A	2700	1½	1½	1	½	13⅝	11¼	22⅝	20⅛	9
10	4000	2	2	1	½	14½	14½	25¾	21¼	9⅜
11	7000	2½	2½	1½	¾	16¾	15	28⅞	26¼	17½
12	12000	3	3	2	¾	16⅝	22⅝	36⅞	25¼	18¾

The above capacities are based upon a minimum distance of 6 in. between bottom of trap and water line of boiler. The capacities increase as this distance above water line increases. Further capacities upon request.

DUNHAM MEDIUM PRESSURE TRAP

This embodies the principle so successfully used in the Dunham Radiator Trap, and is just as simple and satisfactory.



Size	Pipe Connection, In.	Capacity, Water per Hour, Lb.
No. 13	½	100
No. 14	¾	200
No. 15	1	400

Always state operating pressure when ordering.

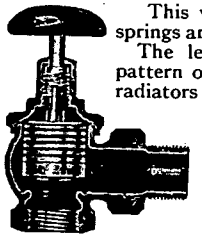
Designed for steam pressures higher than those used in heating systems. It handles air and condensate. Adapted for process work, hospital sterilizers and distilling apparatus, steam tables and kitchen equipment where a steam pressure of from 0 to 60 lb. is used.

Dunham Packless Radiator Valve

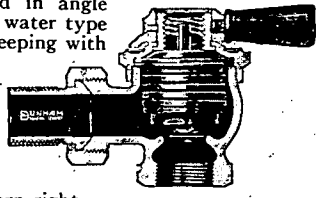
This valve is really "packless." Neither packing of any kind nor any springs are used in its construction. It is built in two specific styles.

The lever handle valve is furnished in angle pattern only and recommended for hot water type radiators with top inlet connection in keeping with the most approved modern steam heating practice. The low bonnet is one of the attractive features of the valve.

The wheel handle valve can be used on any steam system and is furnished as follows: angle pattern, straightway pattern, right hand pattern and left hand pattern.



Type 140—Wheel Handle



Type 100—Lever Handle

Only the best of materials are used. Both types are neat in appearance, and are quick opening and closing valves.

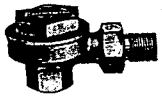
The valve is made packless by means of the bellows construction, consisting of a series of corrugated phosphor bronze diaphragms which permit the free up and down movement of the spindle and valve disc. This construction obviates the use of springs, packing or stuffing boxes of any kind and entirely prevents the leakage of steam, air or water.

Made in following sizes: Lever ½, ¾, 1, 1¼, 1½ in. Wheel ½, ¾, 1, 1¼, 1½, 2 in.

Type 100 made only in angle pattern.

Type 140 made in angle, straightway and corner patterns and can be supplied with wheel or lever handle.

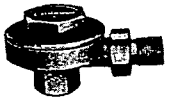
The valves can be supplied with lock and shield, and special extension stems for use on radiators behind grilles, seats, etc., or on ceiling of the room.



1
Trap No. 1

No. 1. All Patterns
Tapping ½"; Capacity 100 sq. ft. Rad.

No. 2. All Patterns
Tapping ½"; Capacity 350 sq. ft. Rad.



2
Trap No. 2

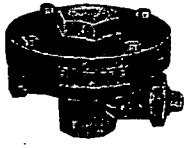
No. 3. All Patterns
Tapping ¾"; Capacity 800 sq. ft. Rad.

No. 4. Angle and Straightway
Tapping ¾"; Capacity 1500 sq. ft. Rad.

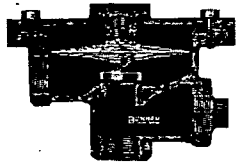


3
Trap No. 3

No. 5. Angle and Straightway
Tapping 1"; Capacity 3000 sq. ft. Rad.

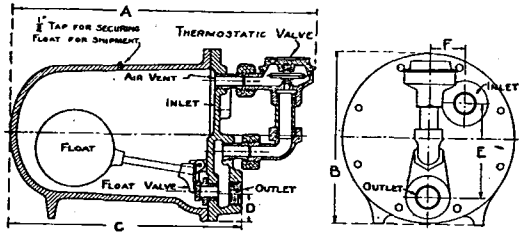


4
Trap No. 4



5
Trap No. 5

DUNHAM FLOAT AND THERMOSTATIC TRAP

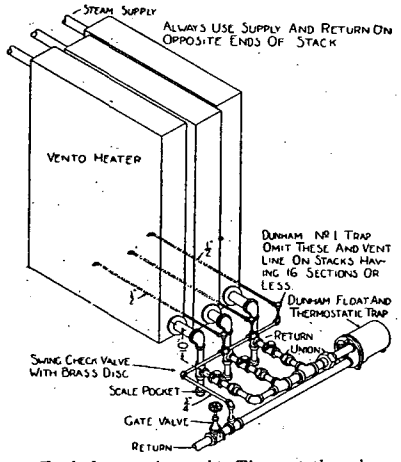


These traps handle large volumes of water and sudden calls for maximum duty. They open automatically for water and air and close for steam. They are suitable on either gravity or vacuum heating systems. The water is handled by the float operated valve which is so constructed that the opening is always sealed with water with no opportunity for steam leakage. The air is handled by the thermostatic valve. They combine the Dunham Thermostatic Principle with the float. They automatically open for air and water and close for steam. This trap adjusts itself slowly like a thermometer to the temperature conditions present and permits a continuous flow, at a rate within its capacity limits, to keep the heaters free from air and water, without waste of steam.

They may be applied to any type or make of cast iron or pipe coil blast heater. They are unsurpassed for dripping low-pressure steam mains and risers, vento heaters, unit heaters, blast coils, domestic hot water heaters, dry kilns, milk condensers, evaporators, paper machines and any industrial heater in which low-pressure steam (not exceeding 10 lbs. gauge) is used as a heating medium.

This type of trap not only drains the heater of its water of condensation but automatically releases the air, thus obtaining as nearly 100 per cent heating efficiency as may be obtainable, which results in the operation of the equipment at its maximum potential output.

In many industrial processes, it is desirable to operate on a vacuum, a condition that is fully met in this type of trap.



Typical connections using Thermostatic and Float Trap on a Vento Heater

Size	Pipe Connection, In.	Capacity. Direct Radiation, Sq. Ft.
No. 22	¾	3,000
No. 23	1	4,000
No. 16	¾	6,000
No. 17	1	7,000
No. 18	1¼	9,000
No. 19	1½	11,000
No. 20	2	16,000

Dunham Pressure Reducing Valve

Made only in standard weight for a pressure range of 125 lb. down on high side, to 10 lb. and atmosphere on low side, in straight and expanded outlet patterns.

Dunham Vacuum Pump Governor

Used on steam driven vacuum pumps to control vacuum in vacuum return lines. Made in all sizes from ½ to 2 in., inclusive.

Dunham Damper Control

The Dunham Diaphragm Damper Regulator controls the steam pressure in ounces. It operates check and draft damper with chains.

Dunham Air Eliminator

Used in connection with the Dunham Home Heating System for venting the air from the system. Two types. Capacities respectively 2000 and 6000 sq. ft. radiation.

Dunham Oil Separator

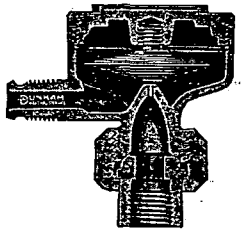
Made in all sizes from 1½ to 6 in. Flanged connections.

Dunham Strainer

Has a large brass screen basket for catching and holding the dirt; easily accessible for cleaning and at once commends itself for this purpose. Made in all sizes from ¾ to 6 in.

Dunham Air Line Valve

The principle of operation is identical, and design similar, to the Dunham Radiator Trap. Its efficiency is high, and service in connection with air line systems invaluable. Can be furnished with either ⅛ or ¼-in. radiator connection. Air piping is required in connection with its use. It must not be subjected to steam pressures exceeding 10 lb. gage.



Dunham Air Line System

This is a one-pipe steam system using a Dunham Air Line Valve on each radiator, with a system of air line piping which may discharge the air by gravity, or be attached to an air line Vacuum Pump. This system is particularly adaptable in making old one-pipe heating systems more efficient. It is easily and economically installed, and insures the quick removal of air from the radiators.

The Dunham Home Heating System

This is specially for the home or small building. It uses steam at very low pressure. Steam is admitted into the radiator by the Dunham Packless Radiator Valve, where it is retained by the Dunham Radiator Trap until it has given off its heat, when, as water, it passes through the trap together with the air, and back to the boiler through the return piping. The air is released by the Dunham Air Eliminator, and the water returns naturally to the boiler. The design is such that a partial vacuum can be obtained on receding fire, with water continuing boiling. Hot water pattern radiators with top inlet connections are required. The end of each steam main is vented through a Dunham Trap into the return piping, and is dripped through wet or dry drip pipe directly back to the boiler return header.

The Dunham Return System

This System differs from the Home Heating System in that it makes use of the Dunham Return Trap in place of the Dunham Air Eliminator, which introduces the added feature of a positive automatic return of water to the boiler when it is desired to raise the steam pressure.

The feature of a positive return under varying steam pressures makes this Dunham System particularly adaptable to apartment houses, small hotels and medium size commercial buildings, schools and churches. This System makes possible the modernizing of old one-pipe and two-pipe gravity systems, and eliminates the sputtering, leaking air valves which are such trouble makers in these old heating jobs.

The Dunham Vacuum System

Simplicity is the key note of Dunham design. There is the system of steam mains and piping to supply all radiation, and the return piping to carry away the air and water of condensation by means of a vacuum pump. Steam may be supplied direct from boiler, or through a Dunham Reducing Valve, where boiler pressure is too high for direct service. Or exhaust steam may be used, supplemented by live steam through a Reducing Valve.

Bulletins

Bulletins of standard architectural size with detailed information covering each System, and all products, including roughing-in dimensions, will be furnished on request.

The Fulton Company

Knoxville, Tennessee

NEW YORK
Hudson Terminal Bldg.
50 Church Street

PHILADELPHIA
Drexel Bldg.
4th and Chestnut Streets

SALES OFFICES:
DETROIT
Book Bldg., Washington Boulevard
REPRESENTATIVES IN ALL PRINCIPAL CITIES

CHICAGO
Wrigley Bldg.
Michigan Boulevard

BOSTON
Federal Bldg.
136 Federal Street

Patentees and manufacturers of Sylphon products. Sylphon Automatic Air and Vent Valves; Packless and Leakless Valves, Thermostats for regulating temperatures of homes by warm air furnaces, steam, vapor or hot water boilers; Temperature and Pressure Regulators, Temperature Regulating Radiator Covers; and other Heating Specialties.

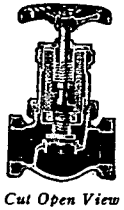
Advantages

All Sylphon devices embody the seamless, one-piece bellows of drawn metal shown at right. There is not a bit of solder throughout its length—no chance for leaks or breaks. It is a feature found exclusively in Sylphon Products. Sylphon diaphragms or bellows are made in sizes ranging from 1⅛ to 12 in. O. D.



No. 304 Standard Pressure Packless Valve

A special alloy Sylphon bellows surrounds the stem and turning parts, forming an ever-tight barrier to leakage of steam around the stem, *no packing*, hence no need of repacking.



Cut Open View

This valve is largely used for hazardous liquids and is approved by the Underwriters' Laboratory (No. M. H. 988.) Made in valve sizes ½ in. to 2 in. inclusive. For pressures up to 150 lbs.

SPECIFICATION—Install where shown on plans, a Sylphon Standard Pressure Packless Valve, as manufactured by The Fulton Company, Knoxville, Tenn., known as No. 304. Size (state size).

No. 510 Sylphon Vent Valves for Primary Heating Coils

For venting air from large heating coils used in stacks and in indirect heating with fan blowers, where low-pressure steam is used. Venting port $\frac{1}{16}$ in. dia. Has a powerful Sylphon bellows as thermostat which closes valve immediately steam reaches it. Does not close against water. Can be installed in any position. Made entirely of cast brass; ruggedly constructed. Ask for Bulletin RAV-3.

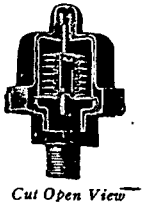


SPECIFICATION—Heating Coils, where shown on plans, shall be vented with No. 510 Sylphon Vent Valves as manufactured by The Fulton Company, Knoxville, Tenn., and installed in accordance with instructions furnished by the manufacturer.

No. 527 Quick Vent Valve

For venting mains, long runs of pipe, indirect stacks, drop risers, and all low-pressure steam jobs where a large amount of air must be expelled quickly.

Vents entire piping system and thereby heating radiators quicker under less pressure. No adjustment. Does not close against water. Venting port $\frac{1}{16}$ in. diameter. Valve connection ⅜ in. pipe thread. Ask for Bulletin RAV-3.

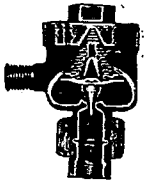


Cut Open View

SPECIFICATION—The ends of long runs of pipe, risers or loops shall be vented with a No. 527 Sylphon Quick Vent Valve, as manufactured by The Fulton Company, Knoxville, Tenn.

No. 410 Sylphon Air Line Valve

An automatic, non-adjustable air line valve that will silently expel air and condensation, but close against steam. Has as its basic principle the Sylphon thermostat, which will quickly and effectively distinguish between steam and air, freely allowing the air and condensation to pass, but preventing the passage of steam. This means that every inch of radiating surface becomes 100 per cent efficient. Ask for *Bulletin RAV-3.*

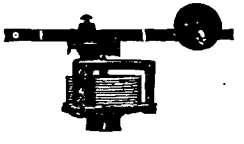


Cut Open View

SPECIFICATION—All radiators to be equipped with Sylphon Air Line Valves known as (either No. 410 or No. 410-A), as manufactured by The Fulton Company, Knoxvil.e, Tenn.

No. 22 Steam Damper Regulator

Used to control the dampers on steam heating boilers. A simple, accurate regulator which will control the draught so as to maintain a constant steam pressure up to 5 lb. This regulator is sensitive, positive in action and will last a life time, due to the Sylphon one-piece, seamless, solderless, flexible metal bellows which it contains as diaphragm. Ask for Bulletin RD-3.



SPECIFICATION—The boiler shall be equipped with a No. 22 Sylphon Steam Damper Regulator, as manufactured by The Fulton Company, Knoxville, Tenn., and installed in accordance with *instructions of the manufacturer.*

No. 22 Junior Steam Damper Regulator

This Regulator is identical in construction with No. 22 except that it contains a smaller Sylphon bellows as its diaphragm and is therefore suitable for *small steam boilers* or those having light dampers which do not require much power for their operation. Will maintain a constant steam pressure up to 8 lbs. gauge.

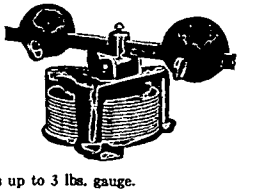


Ask for Bulletin RD-3

SPECIFICATION—The boiler shall be equipped with a No. 22 Junior Sylphon Steam Damper Regulator, as manufactured by The Fulton Company, Knoxville, Tenn., and installed in accordance with instructions of the manufacturer.

No. 924 Steam Damper Regulator

For low pressure steam boilers where extra sensitiveness and greater power are required to operate the damper. Is identical in construction with No. 22 except that it contains a larger Sylphon bellows as its diaphragm, and distance between rocker pivot and plunger pivot is greater. Will operate with pressures up to 3 lbs. gauge.

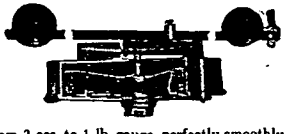


Ask for Bulletin RD-3

SPECIFICATION—Boiler shall be equipped with a No. 924 Sylphon Steam Damper Regulator as manufactured by The Fulton Company, Knoxville, Tenn., and installed in accordance with instructions of the manufacturer.

No. 925 Vapor Damper Regulator

Specially designed to control dampers on boilers used with vapor heating systems. Extremely powerful and sensitive. Has extra large flexible Sylphon bellows as diaphragm. One ounce change in vapor pressure produces a 6¼ lbs. force to open or close dampers. Operates from 2 ozs. to 1 lb. gauge, perfectly smoothly and will not "flutter" under any condition.

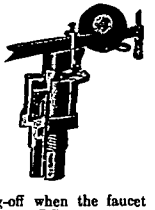


Ask for Bulletin RD-3

SPECIFICATION—The boiler shall be equipped with a No. 925 Sylphon Vapor Damper Regulator, as manufactured by The Fulton Company, Knoxville, Tenn., and installed in accordance with instructions of the manufacturer.

No. 45-A Hot-Water Damper Regulator

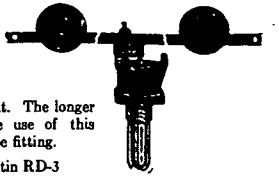
Used to control the dampers on hot water heating boilers. Simple, accurate regulators which will control the draft so as to maintain a constant temperature of the water at any point between 120 deg. and 220 deg. fahr. They prevent the temperature of the water from rising higher than necessary, insuring faucet water of even temperature every hour of the day. Installed on domestic hot-water heaters they prevent the generating of steam in the system, thus eliminating the disagreeable sputtering and blowing-off when the faucet is open.



Ask for Bulletin RD-3.

No. 45 Hot-Water Damper Regulator

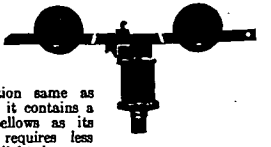
Same as No. 45-A except bulb is 4 in. instead of 2 in. long and rocker does not have adjustment. The longer bulb permits the use of this regulator in a pipe fitting.



Ask for Bulletin RD-3

No. 46 Hot-Water Damper Regulator

This regulator with bulb 1 in. long, is designed especially for small hot-water-heating boilers, or those having light dampers, also, domestic hot-water supply heaters. Construction same as No. 45 except that it contains a smaller Sylphon bellows as its diaphragm, as it requires less power to operate the light dampers of such heaters. Also suitable for laundry heaters, garbage burners, garage heaters, etc. Ask for Bulletin RD-3.



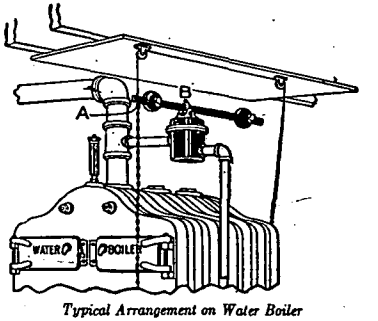
SPECIFICATION—(Boiler, heater, or tank heater) shall be equipped with a No. (45, 45-A, 45-B or 46) Sylphon Hot-Water Damper Regulator, as manufactured by The Fulton Company, Knoxville, Tenn., the regulator to have a temperature range of (specify temperature range. No. 45 and 45-A have temperature range of 120 deg. to 220 deg. fahr.; No. 45-B has temperature range of 100 deg. to 200 deg. fahr. No. 46 has temperature range of 130 deg. to 200 deg. fahr.) and to be installed in accordance with instructions furnished by the manufacturer.

Nos. 42, 43, 44, Hot Water Damper Regulators

These regulators are used where conditions require side instead of direct connections. The hot water circulates around an inner bulb containing a volatile liquid, which in turn causes the Sylphon bellows to expand or contract as the temperature of the water rises or falls, thus closing or opening the draft dampers. Ask for bulletin RD-3.



SPECIFICATION—(Boiler heater or tank heater) shall be equipped with a No. (42, 43, or 44) Sylphon Hot Water Damper Regulator, as manufactured by The Fulton Company, Knoxville, Tennessee, the regulator to have a temperature range of (specify—No. 42 controls from 120° to 180° F.; No. 43 from 160° to 220° F.; No. 44 from 190° to 240°F.) and to be installed in accordance with instructions furnished by manufacturer.

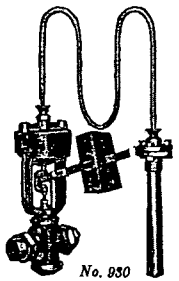


Typical Arrangement on Water Boiler

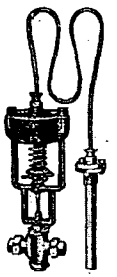
No. 930 and No. 931 Temperature Regulators for Control of Liquids

Used to automatically control temperatures of liquids heated by steam, and especially for hot-water supply tanks in apartments, hotels, clubs, etc., and regularly furnished with a temperature range of 140° to 180° F. Special regulators can be furnished with adjustment for 20° above or below the operating point for temperatures not lower than 10° nor higher than 315° F.

No. 930 has lever and weight method of adjustment; No. 931 has spring type. The extreme sensitiveness, positive action and simplicity of these regulators place them in a class by themselves and make them applicable in many ways. No. 931 is made in valve sizes ½ in. to 2½ in. *inclusive*, and No. 930 *in sizes* ½ *in. to* 8 in. inclusive.



No. 930



No. 931

Temperature Ranges Nos. 930, 931, 934, 935, 980, 981

No.	Range	No.	Range
21	10 to 50° F.	28	180 to 220° F.
22	20 to 60° F.	29	190 to 230° F.
23	40 to 80° F.	30	210 to 250° F.
24	60 to 100° F.	31	220 to 260° F.
25	100 to 140° F.	32	230 to 270° F.
*26	140 to 180° F.	33	245 to 285° F.
27	160 to 200° F.	34	275 to 315° F.

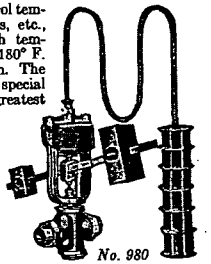
*For service water heating.

Nos. 932 and 942 are 10 degrees higher.

On special order at $2.50 net additional cost, regulators Nos. 930, 931, 932, 935, 942, 980 and 981 will be furnished with reversed valve interior for controlling cooling mediums.

No. 980 and No. 981 Temperature Regulators for Control of Air

Used to automatically control temperature of air in dry rooms, etc., and regularly furnished with temperature range of 140° to 180° F. Other ranges upon application. The thermostatic bulb, of our special "star-shaped" design, gives greatest area of exposed surface to mass of any design known. It may be placed at any point in room, and is connected with operating valve by a flexible tube of required length.

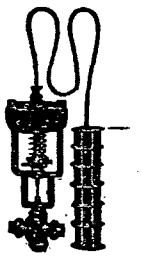


No. 980

Furnished in either lever and weight type (No. 980) or spring adjusting type (No. 981). No. 980 is made in valve sizes ½ in. to 5 in. inclusive and No. 981 in sizes ½ in. to 2½ in. inclusive.

Valves—Double-seated, balanced type, bronze disc and seats. Bronze bodies fitted into bronze unions, in sizes ½ in. to 1½ in. inclusive. Sizes 2 in. and above have iron bodies, bodies flanged and drilled standard. Companion flanges furnished at extra cost. **Flexible metal tubing** 8 ft. long. Supplied longer on order.

Upon application a chart will be furnished showing how to determine size of regulator needed for any given condition. Ask for chart and Bulletin RTR-110.

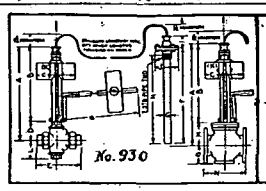


No. 981

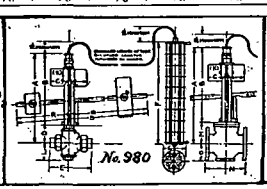
SPECIFICATION—Install where shown on plans, a Sylphon Temperature Regulator (Nos. 930, 931, 980 or 981) as manufactured by The Fulton Company, Knoxville, Tenn.; regulator to have a temperature range of (specify) degrees F. and valve of (specify) inches in size, ground for steam pressure of (specify) lbs. with tubing (specify) ft. long.

Principal Dimensions, Prices, Etc., of No. 930, No. 931, No. 980 and No. 981 Sylphon Temperature Regulator

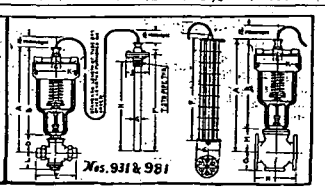
Valve Sizes, Inches	½	¾	1	1¼	1½	2	2½	3	3½	4	5	6	8
st prices 930	$60	$65	$70	$75	$80	$ 90	$ 95	$100	$110	$120	$175	$225	$275
st prices 931	$60	$65	$70	$75	$80	$ 90	$ 95						
st prices 980	$70	$75	$80	$85	$90	$100	$110	$125	$140	$150	$225		
st prices 981	$70	$75	$80	$85	$90	$100	$110						
ılb thread IPS 930	1"	1"	1"	1"	1"	1¼"	1¼"	1¼"	1¼"	1¼"	1¼"	2½"	2½"
ılb thread IPS 931	1"	1"	1"	1"	1"	1¼"	1¼"						
ılb length 930	16"	16"	16"	16"	16"	16"	16"	24"	24"	24"	24"	24"	24"
ılb length 931 and 981	16"	16"	16"	16"	16"	16"	16"						
ılb length 980	16"	16"	16"	16"	16"	16"	16"	16"	16"	16"	16"		
ver bar length 930	24"	24"	24"	24"	24"	24"	24"	36"	36"	36"	36"	36"	36"
ver bar length 980	41"	41"	41"	41"	41"	41"	41"	43"	43"	43"	43"		
eight A+L 930	14⅞"	15¼"	16⅛"	17⅜"	17⅝"								
eight A+O 930						19⅜"	20⅜"	23½"	24⅛"	25⅛"	27⅛"	29⅛"	31⅜"
eight A+L 931 and 981	18½"	18⅞"	19½"	20¼"	20¾"								
eight A+O 931 and 981						21⅛"	22⅛"						
eight A+L 980	14⅞"	15¼"	16⅛"	17⅜"	17⅝"								
eight A+O 980						19⅜"	20⅜"	23½"	24⅛"	25⅛"	27⅛"		
ce to face 930	(E) 5⅜"	(E) 5⅞"	(E) 6½"	(E) 7¾"	(E) 8⅜"	(N) 7"	(N) 7¾"	(N) 8⅝"	(N) 9½"	(N) 10¼"	(N) 12¼"	(N) 14¼"	(N) 18½"
ce to face 931 and 981	(E) 5⅜"	(E) 5⅞"	(E) 6½"	(E) 7¾"	(E) 8⅜"	(N) 7"	(N) 7¾"						
ce to face 980	(E) 5⅜"	(E) 5⅞"	(E) 6½"	(E) 7¾"	(E) 8⅜"	(N) 7"	(N) 7¾"	(N) 8⅝"	(N) 9½"	(N) 10¼"	(N) 12¼"		
idth incl. ⟩ Q 980	26"	26"	26"	26"	26"	26"	26"	27¼"	27¼"	27¼"	27¼"		
ver bar ⟩ R 980	14⅝"	14⅛"	14⅝"	14⅝"	14⅝"	14⅝"	14⅝"	15¾"	15¾"	15¾"	15¾"		



No. 930



No. 980

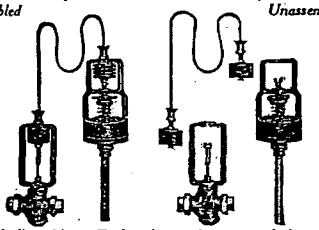


Nos. 931 & 981

No. 932 Sylphon Temperature Regulator

Detachable Tube Type: This is the latest development in self-contained regulators, and on account of its flexibility of installation is very popular with the heating trade. This regulator is composed of three distinct and separable units:

Assembled *Unassembled*



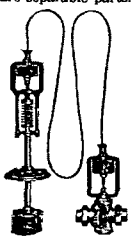
valve, bulb, tubing. Each unit may be separately installed, removed or replaced as the case may be. If the flexible tubing should become damaged or broken, the power transmitting unit may readily be replaced by loosening two lock nuts, and the repair part slipped into place. Movement is transmitted by liquid pressure acting between two small Sylphon bellows and is frictionless. Liquid is non-freezing.

These features are patented and possessed by no other regulator. One transmission unit fits all regulators having valve sizes ½ in. to 1¼ in. inclusive; another unit for valves 1½ in. to 4 in. inclusive. Ask for Bulletin RTR-110.

SPECIFICATION—Install where shown on plans No. 932 Sylphon Temperature Regulator as manufactured by The Fulton Company, Knoxville, Tenn.; regulator to have a temperature range of (specify) degrees F., and valve of (specify) inches in size, ground for steam pressure of (specify) lbs. with tubing (specify) ft. long.

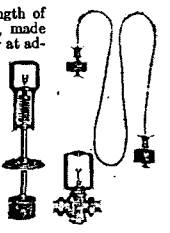
No. 942 Sylphon Temperature Regulator

Separable Transmission Type: For control of air temperatures in ducts of fan and blower heating systems where valve must be at some distance from thermostatic head. Easily installed, as valve, transmission unit and thermostatic head are separable parts.

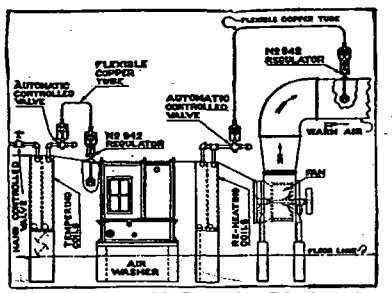


Assembled

Standard length of stem is 12 in., made longer on order at additional cost. Regulator may be installed in any position—either from top, bottom or side of duct. Thermostatic head removable from stem, so that hole cut thru duct wall need be only large enough to pass a ¾ inch pipe. Standard length flexible tubing is 8 ft., longer on order at additional cost. Made in valve sizes ½ to 4 in., inclusive.



Unassembled



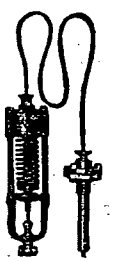
No. 948 as installed in Duct and on Reheating and Tempering Coils

Valves—Double seated balanced type, with bronze discs and seats. Bronze bodies fitted with bronze unions in sizes ½ to 1½ in., inclusive. Sizes 2 in. and above have iron bodies, bodies flanged. Fitted with companion flanges on order at additional cost. Ask for Bulletin RTR-110.

SPECIFICATION—Install in duct where shown on plans No. 942 Separable Transmission type Sylphon Temperature Regulator as manufactured by The Fulton Company, Knoxville, Tenn. Regulator to have a temperature range of (specify) degrees fahr. with valve of (specify) inches in size ground for steam pressure of — lbs., a transmission tubing of (specify) ft. long and extension stem of (specify) inches long.

No. 934 Sylphon Temperature Regulator

For control of liquids. Made in valve *sizes of ¼ and ⅜ in. only, and for steam* pressures under 100 lb. For controlling temperature of steam tables, pasteurizing and sterilising apparatus, size box on slashers, tempering tanks, percolators, glue kettles, and small tanks of all kinds where a minimum amount of steam, accuracy of control, and compactness of instrument are required. Valves are all-bronze, single seated, needle type with screw ends right-handed threads. Ask for Bulletin RTR-104.



No. 934

SPECIFICATION—Install where shown on plans for control of (specify) No. 934 Sylphon Temperature Regulator, as manufactured by The Fulton Company, Knoxville, Tenn. Regulator to have a temperature range of (specify) degrees fahr., with valve of (specify) inches in size, ground for steam pressure of (specify) lbs. and tubing (specify) ft. long.

No. 935 Sylphon Temperature Regulator

For control of liquids or air. Made in valve sizes ¼ to 1½ in., inclusive. (Sizes ¼ and ⅜ in. are for steam pressures under 100 lb. only.) For controlling temperatures of open *liquor vats, tanks, dryers, dry rooms, warming* ovens, proofing rooms, etc. May be installed in any position. Extension stem is regularly furnished 12 in. long, but can be made any length on special order. Valves are double seated balanced type with bronze discs and seats and fitted with unions, except ¼ and ⅜ in. sizes, which are all-bronze single seated needle type, with screw ends right-hand threads. Ask for Bulletin RTR-104.

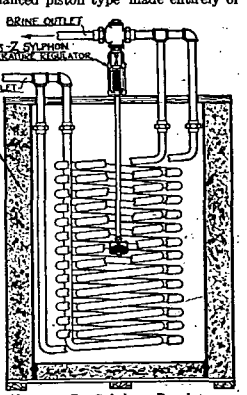


No. 935

No. 935-Z for Control of Cold Storage Rooms and Boxes or Drinking Water

When used for control of calcium chloride brine, valves are ½ *to 1½* in., incl., balanced piston type made entirely of bronze and fitted with bronze unions. Temperature ranges: 10° to 50°; 20° to 60°; 40° to 80° F. Ask for Bulletin TR-106.

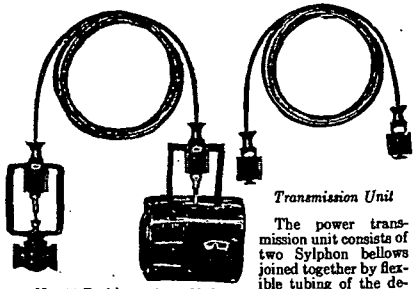
SPECIFICATION—Install where shown on plans for control of (specify) No. 935 (or 935-Z) Sylphon Temperature Regulator as manufactured by The Fulton Company, Knoxville, Tenn. Regulator to have a temperature range of (specify) degrees fahr. with valve of (specify) inches in size, ground for steam (or brine) pressure of (specify) lbs. and extension stem of (specify) inches long.



No. 935-Z—Sylphon Regulator on open type water cooler

No. 11 Sylphon Liquid Transmission Regitherm

The latest development in automatic control of air temperatures for industrial uses. A simple, self-contained, sturdy instrument without complicated mechanism to continually get out of order. Valve is mounted in steam line, Regitherm placed on wall or column 5 ft. above floor, power transmission unit is joined by means of T-slot connections.



No. 11 Regitherm Assembled

Transmission Unit

The power transmission unit consists of two Sylphon bellows joined together by flexible tubing of the desired length, completely filled with a non-freezing liquid. Tubing regularly furnished 25 ft. in length, but can be made any length required. Made in valve sizes ½ to 2½ in., incl. Regularly furnished to operate from 60° to 80° F. Other ranges on application.

Valves—Double seated balanced type, bronze discs and seats. Bronze bodies fitted with bronze unions in sizes ½ to 1¼ in., inclusive. Sizes 2 and 2½ in. have iron bodies; bodies flanged, and drilled standard. Companion flanges furnished at extra cost. Ask for Bulletin RTR-5.

No. 11-Z for Control of Cold Storage Rooms

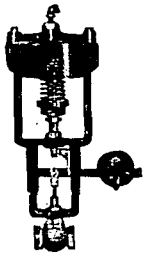
For control of calcium chloride brine furnished with following temperature ranges: 20° to 40°; 35° to 55°; 40° to 60°; 45° to 65°; 55° to 75° F. Ask for Bulletin RTR-106.

SPECIFICATION—Install where shown on plans for control of (specify) No. 11 (or No. 11-Z) Sylphon Liquid Transmission Regitherm as manufactured by The Fulton Company, Knoxville, Tenn. Regitherm to have a temperature range of (specify) degrees fahr., a valve of (specify) inches in size, ground for steam (or brine) pressure of (specify) lbs. and transmission tubing of (specify) ft. long.

No. 955 Sylphon Interlocking Valve

A safety appliance designed to protect oil fired boilers or furnaces by automatically shutting off oil supply when atomising pressure fails, or is reduced below required minimum.

Valve is installed in fuel line and pressure of atomising supply is admitted to Sylphon bellows chamber through a ¼ in. pipe connection at top, so that under normal condition atomising pressure is on the bellows. Pressure acting upon bellows or diaphragm holds valve open. Should pressure drop to predetermined minimum, the latch holding valve open will be immediately released, allowing weighted lever to close valve, thus shutting off fuel supply to burners.



No. 956

Regardless of return of atomising pressure the valve will remain closed until opened by hand. Made in valve sizes from ½ to 2½ in., incl.

Required by Laws and Approved by Insurance Companies—Some states required safety shut-off valves by law, and they are recommended by all insurance companies. The Sylphon interlocking valve has been submitted to test by the Inspection Department of the Associated Factory Mutual Fire Insurance Companies, and has been approved.

Adjustment for Different Pressures—Adjustment is obtained by rotating spanner nut upward to increase and downward to lessen atomising pressure.

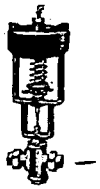
Valves—Globe pattern, single seated, with bronze bodies and discs, screwed ends, with Briggs standard right-hand pipe tapping in both ends. Valves from ½ to 1½ in., inclusive, are suitable for 125-lb. oil pressure. Valves 2 and 2½ in. are for 100-lb. oil pressure. Ask for Bulletin RTR-100.

PRESSURE DATA

Type	Range of Adjustment of Tripping Pressure	Maximum Allowable Atomizing Pressure, Lb.
No. 955-A	3 oz. to 5 lb.	25
No. 955-B	1½ lb. to 15 lb.	50
No. 955-C	5 lb. to 25 lb.	50
No. 955-D	10 lb. to 40 lb.	50
No. 955-E	30 lb. to 100 lb.	125

SPECIFICATION—Install where shown on plans for control of fuel oil supply to (specify) No. 955 Sylphon Interlocking Valve Type (A, B, C, D, E), as manufactured by The Fulton Company, Knoxville, Tenn. Size of valve to be (specify) inches, ground for fuel oil pressure of (specify) lbs. at point where valve is to be installed. Connect atomizing (steam or air) to ¼ in. connection at top of instrument; atomizing pressure (steam or air) to be (specify) lbs.

No. 952 Sylphon Pressure Regulators



No. 952

For controlling the pressure of steam, air and other gases. Useful as a reducing valve or to insure delivery of uniform pressure on a line supplied from a source of variable pressure.

This regulator is extremely sensitive and will reduce pressure to as low as 2-lb. Control pressure may be taken from any desired point. Made in valve sizes ¼ to 4 in.

Valves—Style H valve is double seated balanced type for pressures up to 100 lb.; ½ to 1½ in., inclusive, bronze with screw ends; 2 in. and above have iron bodies.

Style D valve is double seated balanced type for pressures up to 150-lb.; ½ to 1½ in., inclusive, bronze with bronze unions; 2 in. and above have iron bodies.

Style S valve is single seated needle type for pressures up to 100 lb.; bronze with screw ends. Ask for Catalogue RTR-200.

RANGE OF OPERATION OF NO. 952

Style and No. of Regulator	Maximum Pressure Lbs.		Minimum Reduced Pressure in Fractions of Initial Pressure, Lb.						
			Not less than for all sizes	Valve Size, In.					
	Initial	Reduced		¼ and ⅜	½ ¾ 1	1¼ 1½	2 2½	3	4
952 AH	100	25	2	....	1/50	1/40	1/17	1/15	1/10
952 AD	150	25	2	....	1/50	1/40	1/17	1/15	1/10
952 AS	100	25	2	1/50	....	....	....	....	....
952 BH	100	40	3	....	1/50	1/40	1/17	1/15	1/10
952 BD	150	40	3	....	1/50	1/40	1/17	1/15	1/10
952 BS	100	40	3	1/50	....	....	....	....	....
952 CH	100	100	10	....	1/10	1/8	....	....	....
952 CD	150	100	10	....	1/10	1/8	....	....	....
952 CS	100	100	10	1/10	....	....	....	....	....

SPECIFICATION—Install where shown on plans No. 952 (AH, AD, AS, BH, BD, BS, CH, CD, CS) Sylphon Pressure Regulator as manufactured by The Fulton Company, Knoxville, Tenn. Valve to be (specify) inches in size for maximum initial (steam or air) pressure of (specify) lbs. and reduced (steam or air) pressure of (specify) lbs.

The Ja-Nar Radiator Cover

Made of fine furniture steel, lined with heat insulating material. Completely covers either high or low hot water and steam radiators. Can be installed in old homes as easily as in new. Furnished in light or dark oak, mahogany, walnut and various tinted enamels, or to match wood work.

Furnished in three types: 1st, Automatic Temperature Control; 2nd, Manually Operated Temperature Control; 3rd, Uncontrolled Type.

The controlled type is equipped with a thermostatic device which automatically opens or closes the shutters to regulate the heat sent out into the room. Can be set to operate at temperature desired. Ask for Pamphlet on the Ja-Nar.

SPECIFICATION—Install where shown on plans, a Ja-Nar Radiator Cover as manufactured by The Fulton Company, Knoxville, Tenn. The contractor will furnish to The Fulton Company information as to size of radiator and other measurements necessary to build the Ja-Nars. (Specify finish for each room. State whether to be of automatic control type, hand control type or uncontrolled type.)

G. M. Davis Regulator Company

407 MILWAUKEE AVENUE :-: CHICAGO, ILL.

New York Office, 71 Fulton Street

Manufacturers of Automatic Valve Specialties

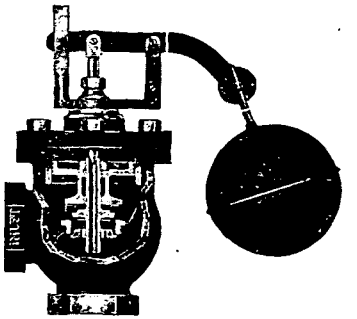


Fig. 318—Float Valve, Globe and Angle

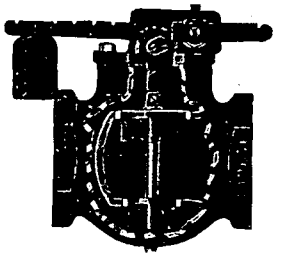


Fig. 321—Back Pressure Valve Horizontal and Vertical

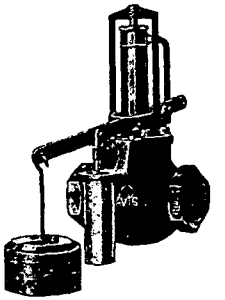


Fig. 305—Pressure Regulator Piston Type

EVERY problem in automatic pressure regulation finds a solution in Davis Valve Specialties.

Engineers and contractors specify and use them because of their well earned reputation for unusually good and long reliable service.

On the next job that you expect to get particularly good results from the pressure regulating devices, let the Davis have a chance to prove their worth.

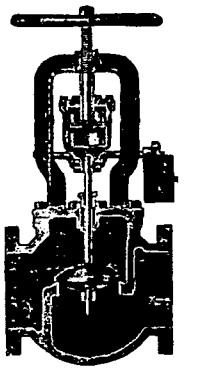


Fig. 332—Stop and Check Valve Globe and Angle

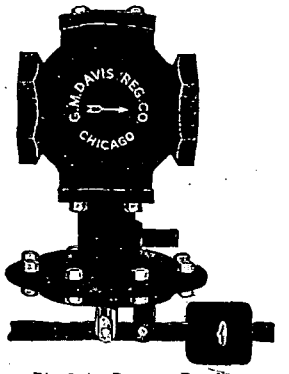


Fig. 311—Pressure Regulator-Diaphragm Type

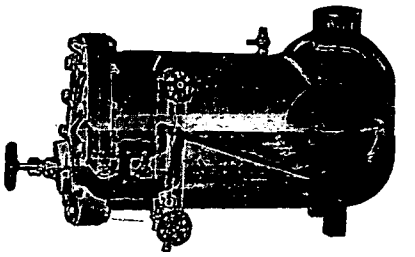


Fig. 828—Steam Trap, Continuous Flow

Hoffman Specialty Co., Inc.

Waterbury, Conn.

GENERAL SALES DEPARTMENT

25 West 45th Street :-: NEW YORK, N. Y.

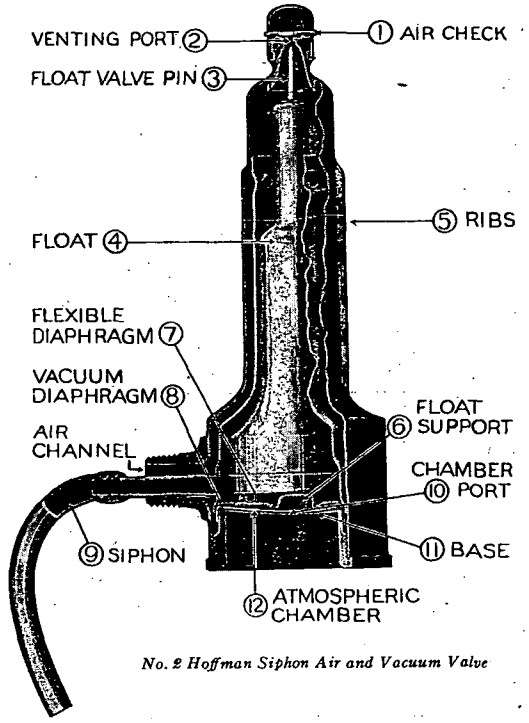
Hoffman Valves and Controlled Heat Equipment

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.



No. 2 Hoffman Siphon Air and Vacuum Valve

HOW THE NEW 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.

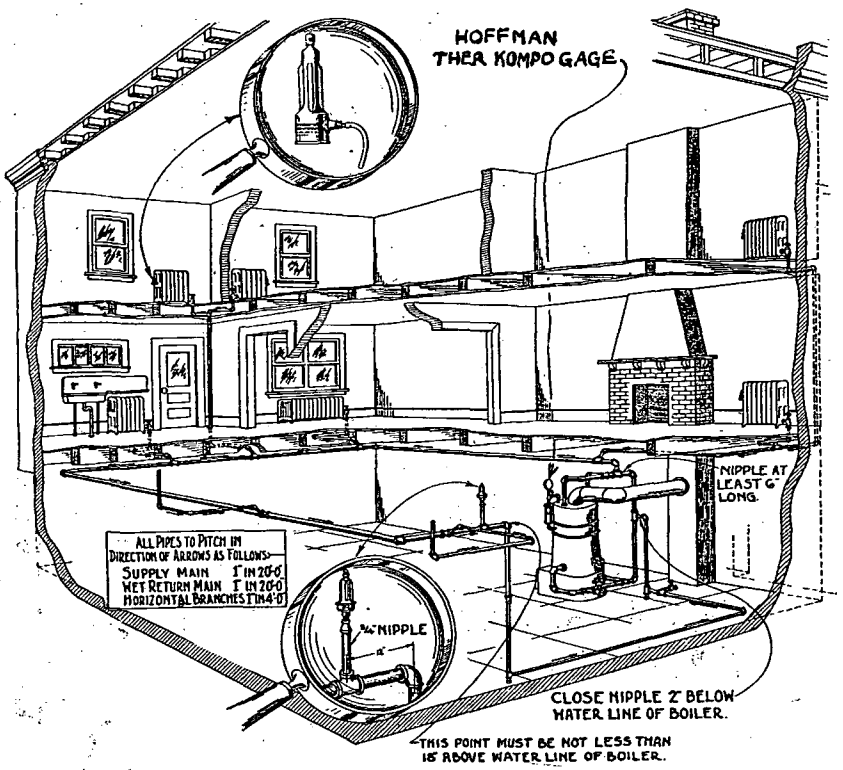
In other words, the air check acts as a vacuum starter, prevents return of air for a short period until the vacuum formed in the valve permits atmospheric pressure, acting through port (10) to force diaphragm (8) upward, raising the float and doubly closing the vent port.

HOW TO VACUUM-IZE A ONE-PIPE STEAM SYSTEM

To enjoy the comfort and economy of this new heating system all that is necessary is to equip the radiators all over the house with these new **No. 2 Hoffman Air and Vacuum Valves**, and if there are one or more air valves on the piping in the cellar, these must also be changed. **The No. 6 Hoffman Vacuum Valve** is best suited for this purpose as it allows those radiators furthest from the boiler to heat up just as quickly as the nearest one.

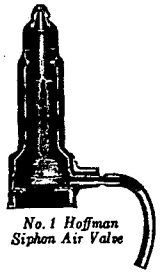
The use of even a single **No. 2 Hoffman Vacuum Valve** on the worst radiator will enable that particular radiator to stay warm after steam pressure has diminished, but with air leaking in at other points complete heating comfort and economy will not be secured unless every valve is a **No. 2 Hoffman.**

Heating contractors and engineers appreciate that while the big air leak in any steam heating system is through the air valves (this leak is stopped by the **No. 2 Hoffman**) there are liable to be other leaks which must be stopped if the system is to be fully efficient. Complete instructions as to what to do and how to do it are sent with the valves and should be carefully observed to get the best service.



Write for Descriptive Circular—Locking the Door Against the Heat Thief

ALL METAL—NON-ADJUSTABLE—THERMOSTATIC



No. 1 Hoffman Siphon Air Valve

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, ⅜ in. Maximum guaranteed operating pressure, 10 lb.

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. See page 506.

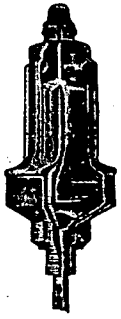
Radiator connection, ⅜ in. Maximum guaranteed operating pressure, 10 lb.

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.

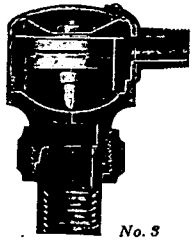
Radiator connection, ⅛ in.; Air Line connection, ¼ in. Maximum guaranteed operating pressure. 10 lb.

The 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.

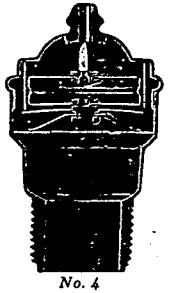
Standard connection, ¾ in., can also be supplied with ¼ in. connection. Maximum guaranteed operating pressure, 10 lb.



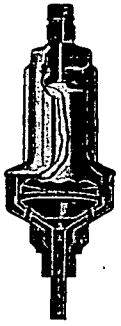
No. 5



No. 3



No. 4



No. 6

The No. 5 is particularly adapted for use in venting: Ends of steam mains; Ends of 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 ⅛ in.; for 3 lb. and over is ⅛ in. Unless otherwise ordered, will be shipped with ⅛ in. port. Maximum guaranteed operating pressure, 10 lb.



No. 10



No. 11

The No. 6 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.

Pipe connection, ⅜ in.; vent port for less than 3 lb. is ⅛ in.; for 3 lb. and over is ⅛ in. Unless otherwise ordered, will be shipped with ⅛ in. port. Maximum guaranteed operating pressure, 10 lb.

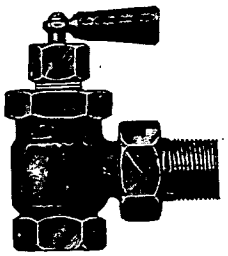
The No. 10 Hoffman Vapor Valve is used for venting the return mains in vapor systems or for other conditions where a large venting capacity is required. The vent port is ¾ in. in diameter.

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.

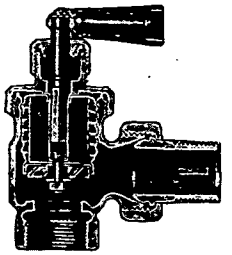
Pipe connection, ¾ in. Maximum guaranteed operating pressure, 15 lb.

Write for Descriptive Circular—The Watchman of the Coal Pile



The No. 17 Hoffman Radiator Valve

VALVE BODY AND TAIL PIECE—Casting of First Quality Steam Metal.
BONNET—Hot Brass Forging.
STUFFING NUT—Rod Brass.
STEM—Drawn Brass Rod.
LEVER HANDLE—Hard Black Fibre.
DISC HOLDER—Drawn Brass Shell.
DISC—Genuine Jenkins Bros.
PACKING—Special Metallic Fibre.
FINISH—Rough Body, Nickel-Plated.
Made in ¾ in. size only. Capacity 200 sq. ft. C. I. Radiation.

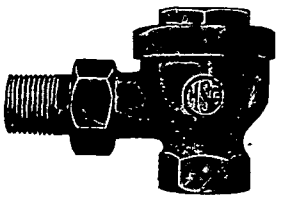


The No. 17 Hoffman Radiator Valve

No. 17 Hoffman Radiator Valve (Quick Opening Valve)

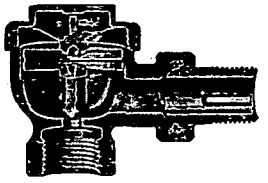
This valve is made in ¾ in. size only, suitable for radiators up to 200 sq. ft.

The valve may be turned from open to shut position or vice versa, with one turn of the lever handle. The valve action is very free, with little friction due to the novel construction of the disc holder and its extension or lead screw for raising and lowering the disc.





Interchangeable Thermo Member



Sectional View

No. 18 Hoffman Return Line Radiator Trap

The thermostat consists of one chamber made by two diaphragms separated by a space ring to which they are fastened. In the center of the bottom diaphragm, the valve pin is attached, the joint being expanded and made absolutely tight. The thermostat is held in its cage by a pin expanded and attached to the top diaphragm, this pin extending through the cage and engaging with the boss on the cap.

The thermostat contains a small quantity of thermostatic fluid, sealed under vacuum insuring extremely sensitive valve action. The fluid is such that its pressure maintains constant relationship with steam pressure and consistency of valve operation under varying pressure is thus obtained.

Chief Features

The valve consistently operates under a pressure range from vacuum to 15 lbs. 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.

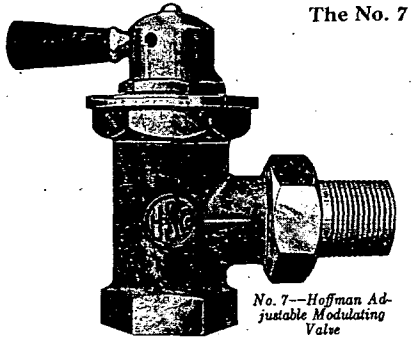
These valves are absolutely non-adjustable and thermostats can be changed from one body to another.

The No. 18 Valve is made in ½ in. size only in Angle, Straightway, Right and Left-hand and Offset Patterns. Normal capacity is 100 sq. ft. of direct cast iron radiation, port diameter ¼ in. in all sizes, operating pressure from vacuum to 15 lbs.

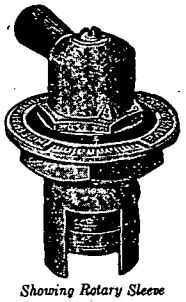
Write for Descriptive Circulars

HOFFMAN "CONTROLLED HEAT" EQUIPMENT

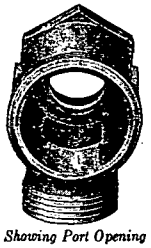
The No. 7 Hoffman Adjustable Modulating Valve



No. 7—Hoffman Adjustable Modulating Valve



Showing Rotary Sleeve



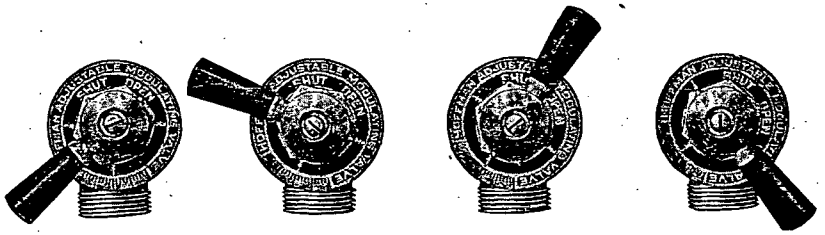
Showing Port Opening

For use in Vapor or Vapor Vacuum systems, is made in ¾ in. size 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.

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.

POSITIONS OF TOP DIAL PLATE FOR VARIOUS SIZES OF RADIATORS



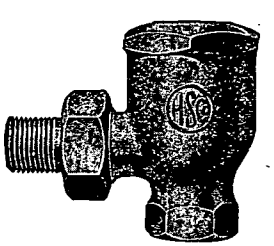
All Graduations exposed 200 sq. ft. | *15 Graduations exposed 150 sq. ft.* | *10 Graduations exposed 100 sq. ft.* | *5 Graduations exposed 50 sq. ft.*

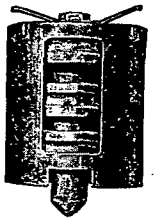


CORRESPONDING POSITIONS OF ROTARY SLEEVE SHOWING PORT AREAS FOR ABOVE GRADUATIONS

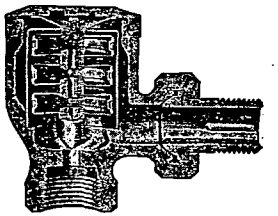
The visible adjustment enables the designing engineer and heating contractor to make a final accurate adjustment which compensates for slight irregularities in pipe sizes, failure to ream pipe, installation of extra fittings not forseen in original layout, etc. The advantages of an adjustable port in forced hot water systems to secure proper balance makes the No. 7 Valve especially adaptable for such use.

Write for Descriptive Circular—Hoffman Controlled Heat





Interchangeable Thermo Member



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.

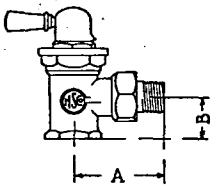
Chief Features

The valve consistently operates under a pressure range from 13 in. of vacuum to 50 lbs. 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.

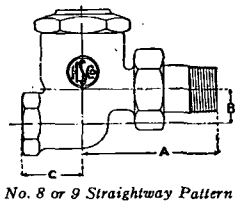
The thermostatic member is removable and may be changed from one valve to another of the same size without adjustment. This feature is appreciated by engineers who require the removal of the thermostat from the valves, until the system is thoroughly cleaned, and likewise by contractors complying with 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.

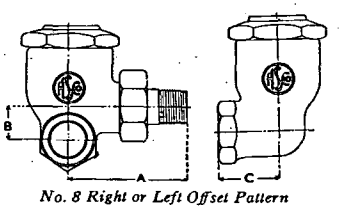
The No. 9 Valve with ¾ in. connection is made in Angle and Straightway Patterns only, and is suitable for 600 sq. ft. of cast iron radiation. For pressures up to 15 lbs. valve has ⅜ in. port, for higher pressures $\frac{3}{16}$ in. port.



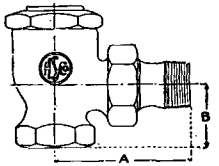
No. 7 Angle Pattern



No. 8 or 9 Straightway Pattern



No. 8 Right or Left Offset Pattern



No. 8 or 9 Angle Pattern

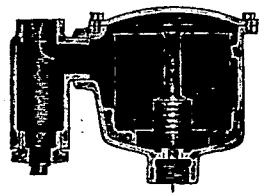
DATA AND DIMENSIONS

STYLE	Size Inches	Diameter Valve Port Inches	Maximum Capacity Square Feet	DIMENSIONS A	B	C
No. 7 Angle	¾	..	200	2⅞	1⅜	...
No. 17 Angle	¾	..	200	2¾	1½	...
No. 8 Angle	½	¼	200	2⅜	1⅛	
No. 8 Straightway	½	¼	200	2⅜	1⅛	1⅛
No. 8 Offset	½	¼	200	2⅜	1⅛	1⅝
No. 18 Angle	½	¼	100	2¼	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	3⅛	1⅛	...
No. 9 Straightway	¾	⅜*	600	3⅛	⅝	1½

*No. 9 Valve furnished with ⅝ in. port for pressures above 15 lb.

Write for Descriptive Circular—Hoffman Controlled Heat

The No. 12 Hoffman Blast Trap is especially well adapted for draining condensation from:



No. 12 Hoffman Blast Trap

Indirect Radiators	Dryers and Drums
Blast or "Vento" Stacks	Hot-Water Generators
Ends of Steam Mains and Risers	Unit Heaters, etc.

Where the operating pressure is not in excess of 30 lb. this valve will take care of large amounts of condensation.

In functioning it distinguishes between steam, heated air and water of condensation giving free discharge of air and condensation.

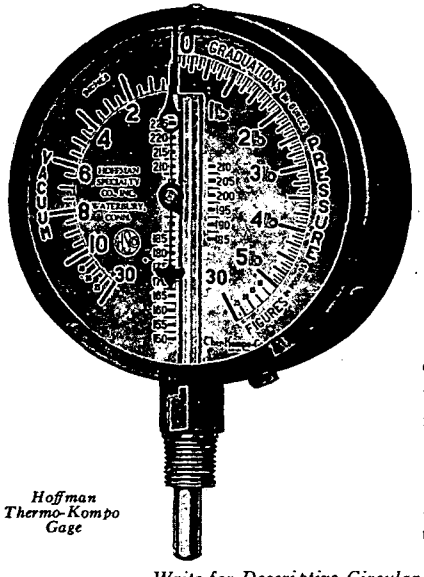
The Trap embodies the desirable feature of open bucket or float traps in that it relieves condensation immediately upon its arrival at the trap regardless of the water temperature. Coupled with the float is a thermostatic member which positively overcomes the chief difficulty with float traps by automatically relieving air as well as condensation from the system.

The normal position of the valve is open and this is held until steam reaches it when closure takes place. If small quantities of condensation flow to the trap the thermostat functions and relieves the water but if larger amounts of condensation, beyond the capacity of the thermostat reach the trap, the float lifts the thermostat from its seat and maximum capacity is obtained.

Table of Nominal Capacities No. 12 Hoffman Blast Trap

Pressure, lbs. per sq. in.	½	1	2	3	4	5
Capacity lbs. per hr.	800	1,000	1,500	1,800	2,000	2,500
Capacity in sq. ft. of radiation on the basis of ¼ lb. of condensation per hr. per sq. ft.	3,200	4,000	6,000	7,200	8,000	10,000

Maximum Operating Pressure, 30 lb. Capacities for over 5 lb. pressure, furnished on application. With Strainer; inlet connection, 1 in.; outlet 1 in. With Strainer; inlet connection, 1¼ in.; outlet, 1 in.



Hoffman Thermo-Kompo Gage

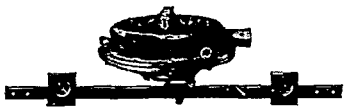
The New Hoffman Ther-Kompo Gage is used on Hoffman Controlled Heat installations or One-Pipe Gravity Steam Heating Systems, equipped with Hoffman No. 2 Vacuum Valves.

It accurately indicates the temperature of the vapor produced in the boiler, whether operating under pressure or vacuum conditions, measuring pressures up to 30 lbs. and vacuum to 30 in.

The Hoffman Ther-Kompo Gage is made in one style only—with pressed steel case, 5 in. diameter dial pressure and vacuum readings in black and temperature readings in red. Pipe connections are ½ in.

When used with the Hoffman Damper Regulator, results in marked fuel economy through more efficient firing of the boiler.

Write for Descriptive Circular—Hoffman Controlled Heat



Hoffman Damper Regulator

One of the most important features of the Hoffman Damper Regulator is the accurate control that only sufficient pressure is maintained to insure circulation to all radiators.

It is extremely sensitive in its action and accomplishes control 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 therefore 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.

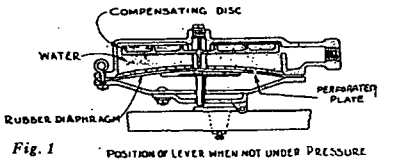


Fig. 1

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.

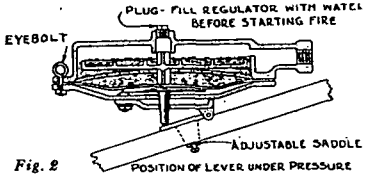
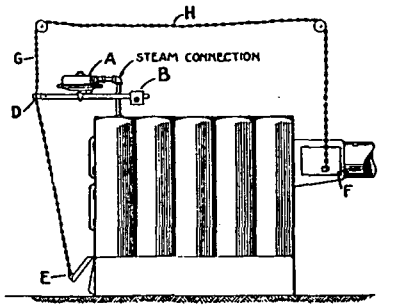


Fig. 2

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.



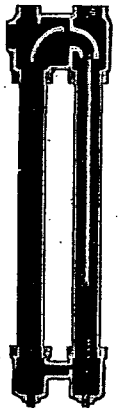
IN MAKING steam connection to boiler, locate Damper Regulator so that chain to "E" and "F" operate freely. Regulator should be set level. Remove plug on top of Regulator and fill with water.

With no pressure on boiler and weight "B" in position on lever, connect chain between "D" and "E" so that draft "E" will be open as wide as required for sufficient draft. Connect "G" over pulley to "F" leaving just enough slack to chain "G" so check draft "F" is closed.

Set weight "B" so lever "D" tilts when steam is raised to pressure to be maintained. If pressure increases, draft "E" will close and check fire. If fire is clean and pressure continues to increase, lever "D" moves downward, opening check draft "F," completely checking fire. As pressure decreases, "F" will *gradually* close and if pressure falls below the desired amount "E" will open.

Connections should be made so that draft "E" opens slightly and check draft "F" opens wide.

Write for Descriptive Circular—Hoffman Controlled Heat

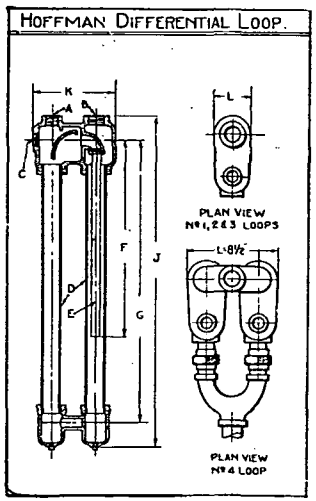


Hoffman Differential Loop

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.

Through its use water is permitted to rise in the return main a certain predetermined amount when the loop functions, blowing over a small quantity of steam which closes the No. 10 or 11 Valve installed on the loop 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 not maintained. 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 and also that by the maintenance of this differential regardless of how high the boiler pressure goes circulation will take place in a radiator which is turned on with the return main vent closed through loop action.



Differential Loops are made in four sizes, having a capacity up to 15,000 sq. ft. of radiation. For larger systems the No. 4 Loops can be installed in a battery or the return mains divided so as to have their load come within the capacity of standard loops.

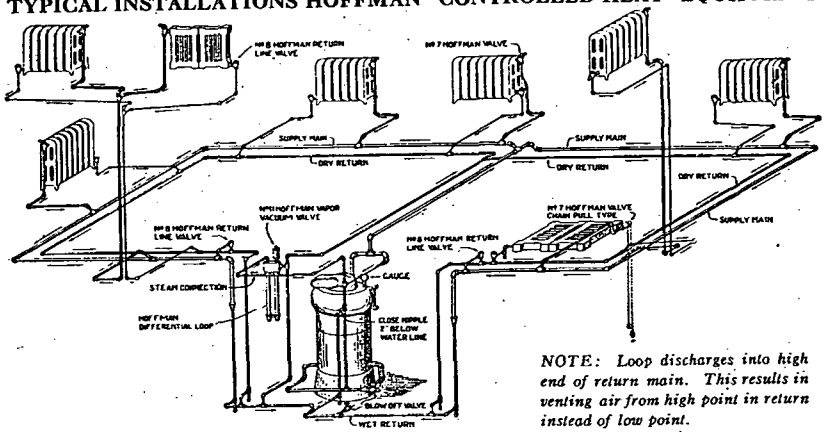
No. 1 and No. 2 Loops should not be used where the low point in the dry return is less than 24 in. above boiler water line; with the No. 3 and No. 4 Loops this distance must be at least 30 in.

DIMENSIONS AND CAPACITIES OF HOFFMAN DIFFERENTIAL LOOPS

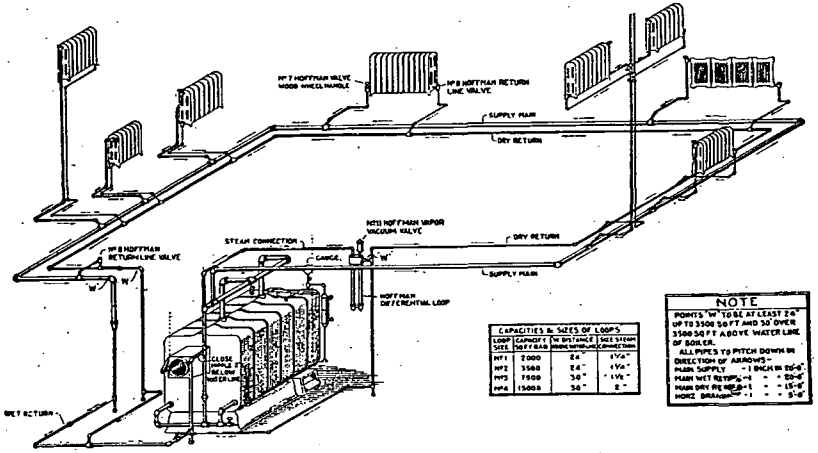
Loop No.	A	B	C	D	E	F	G	J	K	L	Capacity Sq. Ft. Rad.
1	¾″	1¼″	1¼″	1½″	½″	18¼″	26″	30⅜″	7⅝″	3″	2000
2	¾″	1¼″	1¼″	1½″	¾″	18¼″	26″	30⅜″	7⅝″	3″	3500
3	¾″	1½″	1½″	2″	1″	25″	32″	37¾″	10″	3¾″	7500
4	¾″	2″	2″	2″	1″	25″	32″	37¾″	10″	8½″	15000

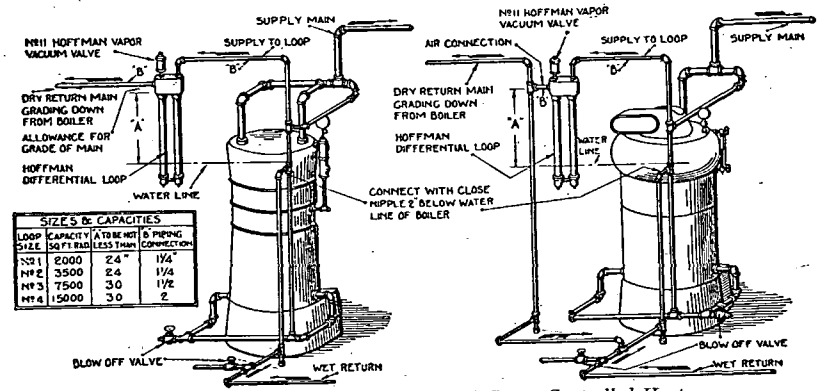
Write for Descriptive Circular—Hoffman Controlled Heat

TYPICAL INSTALLATIONS 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.





Write for Descriptive Circular—Hoffman Controlled Heat

Illinois Engineering Company

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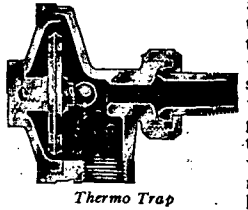
PRODUCTS—Illinois Heating Systems—Eclipse Steam Specialties

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

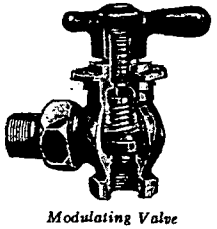
The original vertical seat trap. Dirt does not lie on seat—self cleaning, non-adjustable, positive in operation; durable, will stand 50 lb. steam pressure which shows the great strength of the diaphragm, which is the reason for the long life and durability of these Traps. Thousands in operation for over 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.

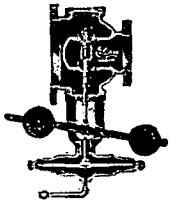
Our Sales-Engineering Organization will be glad to give detailed technical information regarding our products and to advise as to their proper installation.

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

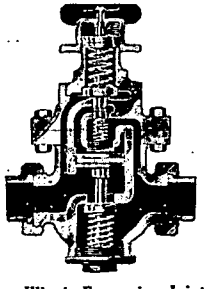
Reducing Valves. In general use on Vacuum or low pressure Heating Systems. Will reduce to 4 oz. pressure from even 150 lb. initial pressure.

The large diaphragm insures sensitive operation.

Made in both straightway and expanded outlet bodies.

Sizes ¾ in. to 12 in.

Eclipse Master Reducing Valve

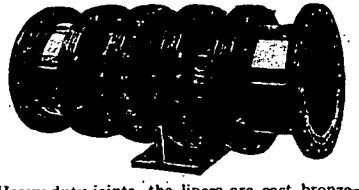


A pilot type valve will reduce from any pressure up to 250 lb. down to 10 lb. and hold reduced pressure constant at all times—even against a "dead end" pipe.

Made of Bronze with monel valves and trimmings.

Sizes ½ in. to 6 in.

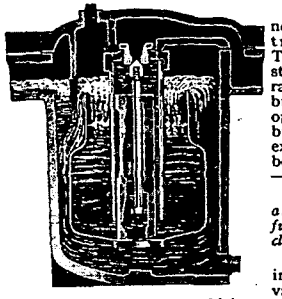
Illinois Expansion Joints - Single and Double Traverse



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 (Patent Applied for)



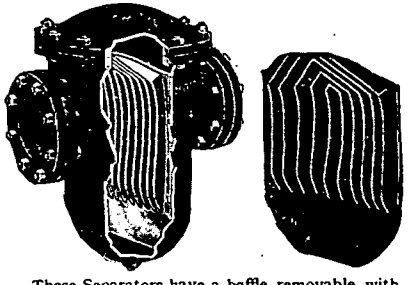
Something new in Steam trap design. The valve and stem are separate from the bucket and only operated by the bucket at its extreme top and bottom travel —*Result*—

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. 302 describes in detail.

Horizontal Oil Separator

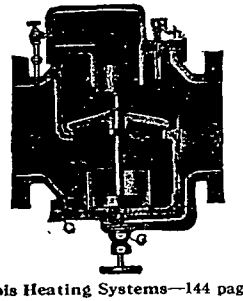


These Separators have a baffle removable without disturbing the piping. Occasional cleaning is necessary for proper elimination of oil.

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, straightway 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

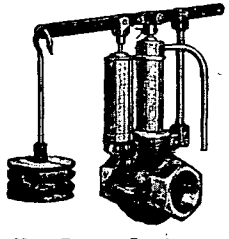
No. 12—Heating Specialties.
No. 22—Vapor System Details.
No. 45—Non-Return Valves
No. 102—Pressure Reducing Valves.
No. 202—Back Pressure, and Relief Valves, Exhaust Heads.
No. 302—Steam Traps.
No. 502—Separators—Oil and Steam.
No. 703—Float and Balanced Valves.

Klipfel Manufacturing Co.

2641-59 West Harrison St.

Chicago, Ill.

Manufacturers of Pressure Regulating Appliances—for the Automatic Control of Steam, Air, Water or Gas



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.

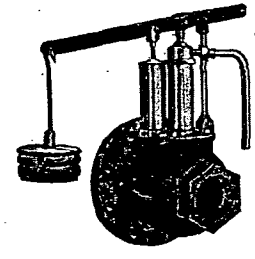
Nos. 1 AND 2 PRESSURE REGULATORS
Piston Type

Automatically reduce any initial steam, air or water pressure to any desired reduced pressure down to 2 lbs. and maintain reduced pressure constantly regardless of fluctuations in the initial pressure, or changes in the demand for steam.

When specified for control of air or water, piston is provided with special leather cup packing at no additional charge. Working parts removable while valve body remains in pipe line.

No. 2 PRESSURE REGULATORS
Piston Type—Expanded Outlet

Similar to No. 1 except have an expanded outlet, allowing use of low pressure pipe of larger size than high pressure supply pipe.

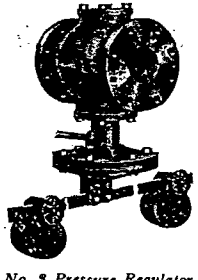


No. 2 Pressure Regulator—Piston Type—Expanded Outlet

Sizes, 1 x 2 to 12 x 24 in. inclusive. Bronze bodies in sizes 1¼ x 2½ in. and under. Iron bodies with bronze inner valves and trimmings in sizes above. Unless otherwise specified, Nos. 2 and 4 will be shipped with inlet screwed and outlet flanged in sizes 1½ x 3 to 4 x 6 in., inclusive, although they can be furnished with other style ends; sizes 4 x 8 in., and above, both ends flanged only.

Nos. 3 AND 4 PRESSURE REGULATORS
Diaphragm Type

Automatically reduce any initial steam pressure to any desired reduced pressure, either below atmosphere or up to 5 lbs. above atmosphere, and constantly maintain reduced pressure regardless of initial pressure fluctuations or changes in the demand for steam. Includes no stuffing box, thus eliminating leakage and friction on valve stem. Diaphragm of ample area insures very close regulation of reduced pressure. Inner valves and seats are bronze, bevel seated, requiring minimum diaphragm movement.



No. 3 Pressure Regulator, Diaphragm Type

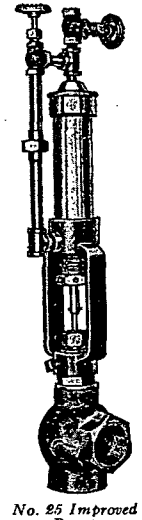
Made in same sizes and style of ends as No. 1 Pressure Regulator, Piston Type.

No. 4 PRESSURE REGULATORS
Diaphragm Type—Expanded Outlet

Similar to No. 3 except have expanded outlet, allowing use of low pressure pipe of larger size than the high pressure supply pipe. Made in same sizes and style of ends as No. 2 Regulator.

Our 80 page Catalog No. 26 with new sectional illustrations, roughing-in dimensions and valuable engineering data is ready for distribution.

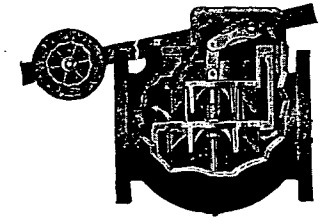
Write for your Copy—TODAY!



No. 25 Improved Pump Governor

No. 28 NOISELESS BACK PRESSURE VALVES

Automatically and noiselessly maintain any desired back pressure, so that exhaust steam may be used for heating, drying and other purposes. For use with non-condensing engines. Because of patented construction, inner valve is effectively stabilized, and cannot pulsate in unison with stroke of engine. Can be operated either horizontal or vertical, but horizontal position is preferable. Iron bodies, bronze inner valves and trimmings.



No. 28 Noiseless Back Pressure Valve

Sizes, 2 to 24 in., inclusive. All sizes made flanged ends; sizes 2 to 8 in., inclusive, also made screwed ends. Unless otherwise specified, sizes 6 in. and under will be shipped screwed ends, while sizes 8 in. and above will be shipped flanged ends.

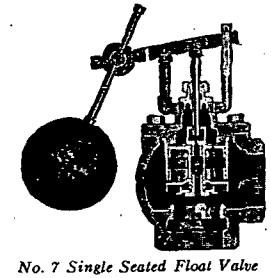
No. 25 IMPROVED PUMP GOVERNORS

Automatically control any type of steam pump, and maintain discharge at a constant pressure. Simple; compact; direct acting; Monel metal stems; bronze inner valves and seats, semi-balanced and taper seated. Made angle and globe patterns in all sizes.

Sizes, ⅜ to 12 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, made screwed or flanged ends, but screwed ends will be shipped, unless ordered flanged. Sizes 7 in. and above made flanged ends only. Made angle and globe patterns in all sizes, and for any steam or water pressure. Angle patterns will be shipped, unless ordered globe.

No. 6 BALANCED FLOAT VALVES

Automatically control the supply of hot or cold water to open tanks and maintain practically a constant water level. Made angle and globe patterns in sizes up to 14 in. inclusive; sizes 16 to 20 in., inclusive are made globe patterns only. The inner valve consists of two perfectly balanced straight side plunger discs and consequently is unaffected by water pressure. The swivel yoke and float level on all sizes can be turned to any desired position. A rosette at the end of lever permits ample adjustment of the seamless copper float. Inner valves and seats are bronze and are fitted for cold water working pressures up to 200 lbs., unless specified for hot water. A special right angle bent lever is furnished when valve is specified for installation in a vertical pipe line.

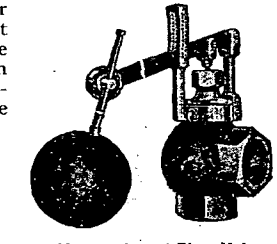


No. 7 Single Seated Float Valve

Sizes, ¾ to 8 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. All sizes are made angle or globe patterns, but angle pattern will be shipped unless specified globe.

No. 7 SINGLE SEATED FLOAT VALVES

Automatically maintain a constant level of hot or cold water in open tanks. Single seated, auxiliary operated. Seat area equal to pipe size. Will not leak. Swivel guide yoke allows float to be located in any position. Angle and globe patterns. All bronze working parts. For working pressure up to 200 lbs.



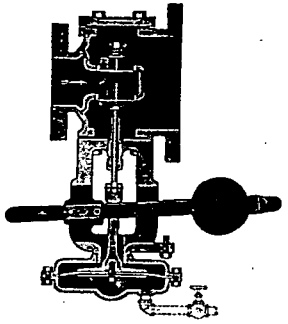
No. 6 Balanced Float Valve

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. Sizes 2 to 6 in. inclusive, made screwed or flanged ends, but screwed ends will be shipped unless specified otherwise. Sizes 7 in. and above, made flanged ends only. All sizes up to 14 in. inclusive are made angle or globe patterns, but angle pattern will be shipped, unless ordered globe. Sizes 16 in. and above are made globe patterns only.

Kieley & Mueller, Inc.

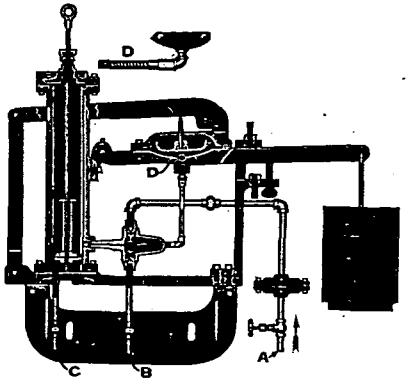
34 West 13th Street **NEW YORK CITY**

Steam Specialties for Power and Heating



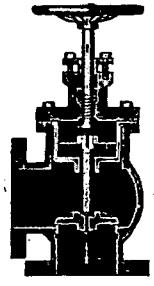
The Kieley Special 98 Pressure Regulator

The Kieley Special 98 Pressure Regulator.—Adapted for reducing steam to vapor and vacuum for heating systems. Other types spring controlled.



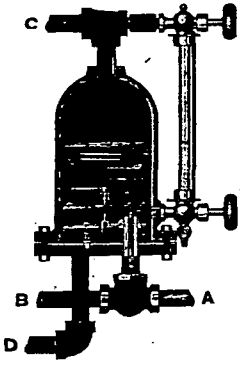
Damper Regulator

Damper Regulator.—Step Action Regulators for high and low pressure. Designed to adjust the Damper position and control the Draft according to requirements.



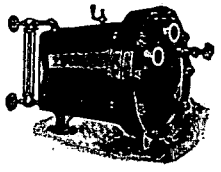
Stop Check Valve

Automatic Cushioned Valves and positive closing.—Constructed in Horizontal and Angle Patterns.



Rapid Type Water Feeder

Rapid Type Water Feeder. — Constructed with valve on outside and with large water space. Made in sizes up to 2 inch.



Steam Trap

Steam Trap, Bucket and Ball Float Types.—Constructed of cast iron or steel with Monel valves. A by-pass valve is furnished integral with Trap.

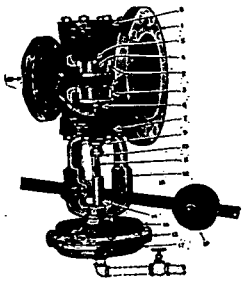
Represented in all Large Cities

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

PRESSURE REDUCING VALVES—used in Low Pressure, Vacuum or Vapor heating systems or any other service where close regulation and absolute control is required.

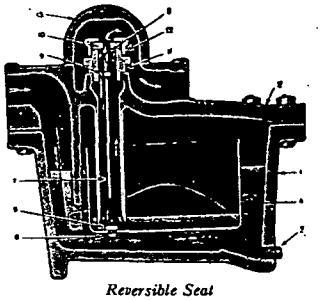


USE

Fig. 155 for initial pressures up to 150 lb. and reducing to service pressures 0-10 lb.
Fig. 185 Single Seated Valves on dead end service where reduced pressure is below 10 lb.

Fig. 235 Spring Weighted type for initial pressures up to 200 lb. and reducing to service pressures above 10 lb. Fig. 255 Single Seated Valves for dead end service such as cooking tables, kitchen utensils, laundry mangles, etc.

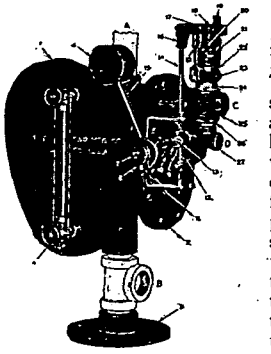
STEAM TRAPS—For draining water of condensation from any steam apparatus or steam mains.



Reversible Seat

SPECIFY

Fig. 685 for pressures up to 250 lb.
Fig. 715 for special low pressures.



No. 785—Low Pressure, up to 15 lbs.

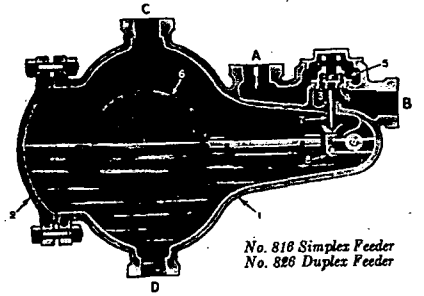
AIR ELIMINATOR AND RETURN TRAPS—Designed for automatically returning water of condensation from low pressure steam or vapor systems direct to boiler and to exhaust the air to atmosphere.

CAPACITIES

Size No.	Inlet In.	Outlet In.	Steam In.	Vent. In.	Capacity Sq. Ft.
1	1¼	1¼	1	¾	6,000
2	1½	1½	1	¾	12,000
3	2	2	1	¾	24,000

McAlear Direct-to-Boiler Water Feeders

For maintaining constant water line in steam boilers. McAlear Automatic Water Feeders prevent boiler fractures from low water, decrease fuel consumption and reduce maintenance expense.



No. 816 Simplex Feeder
No. 826 Duplex Feeder

For oil burner installations—Feeders are equipped if desired, with LOW WATER ELECTRIC CUT-OUTS.

The McAlear line of Power, Heating, Gas and Oil Specialties include: Thermostatic Radiator Traps, Packless Radiator Valves, Air Vents, Grease Extractors, Dirt Strainers, Vacuum Pump Governors, Damper Regulators, Steam Separators, 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.

Jas. P. Marsh & Company

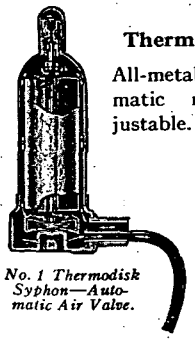
Established 1865

114-124 S. Clinton St. - CHICAGO, ILL.

SALES AGENCIES IN MOST PRINCIPAL CITIES

Thermodisk

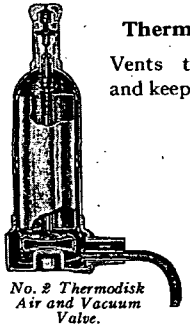
All-metal Automatic non-adjustable.



No. 1 Thermodisk Syphon—Automatic Air Valve.

Thermodisk

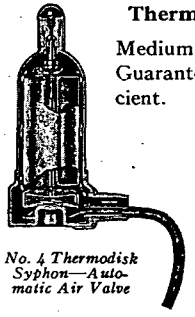
Vents the air and keeps it out.



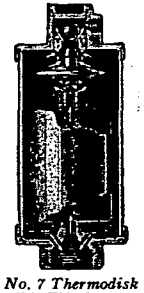
No. 2 Thermodisk Air and Vacuum Valve.

Thermodisk

Medium priced. Guaranteed efficient.



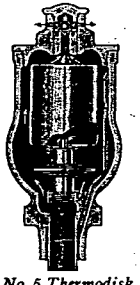
No. 4 Thermodisk Syphon—Automatic Air Valve



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.

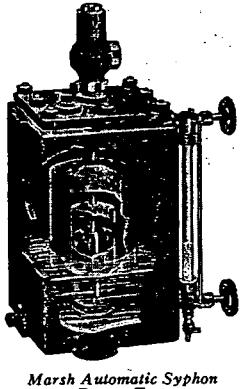
Sizes and capacities for every requirement.



No. 5 Thermodisk Rapid Vent



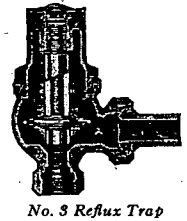
No. 3 Thermodisk Air Line Valve



Marsh Automatic Syphon Return Trap



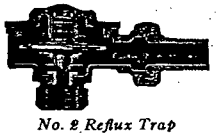
No. 1 Reflux Trap



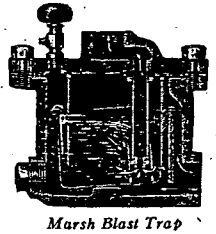
No. 3 Reflux Trap

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.

Marsh Blast Traps for Direct or Indirect Coils and for any location where large quantities of water are to be discharged.



No. 2 Reflux Trap

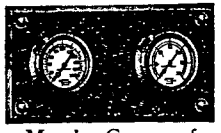


Marsh Blast Trap

Marsh Indicating Gauge



Marsh Gauge Board

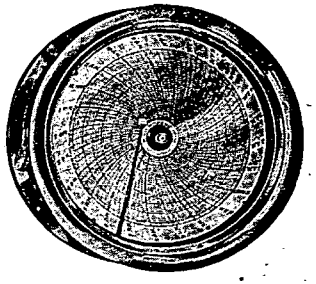


Marsh Gauges for every requirement of indicating Pressure, Vacuum, Altitude, etc.

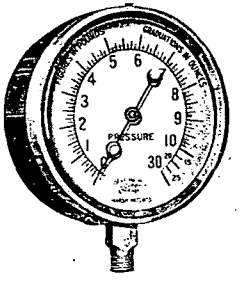
Marsh Recording Gauges where a high grade, accurate instrument is required and where it is desired to match other instruments on Gauge Boards, etc.

We specialize in Gauge Board outfits complete with all instruments.

Marsh Recording Gauge



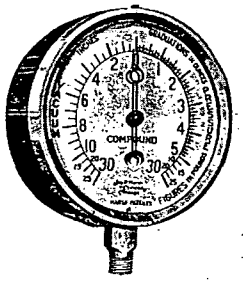
Low Pressure Ounce Gauge



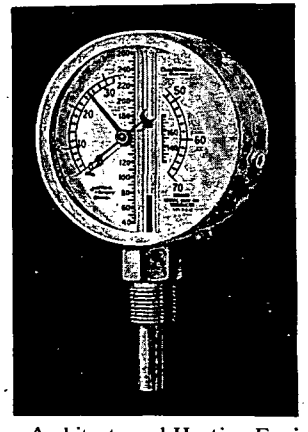
Show exact pressure in ounces and pounds.

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

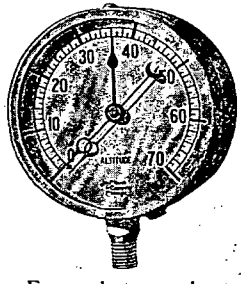


Marsh Ther-Alti-Meter



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.

Mason Regulator Company

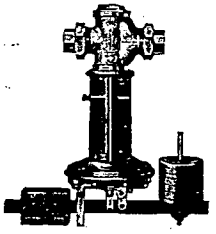
Boston, Mass.

San Francisco, Calif. Montreal, Canada

Manufacturers of
Pressure Regulators and Steam Specialites

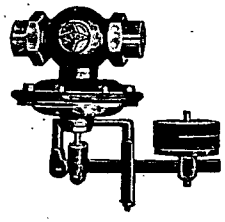


No. 229, Spring Type
Sizes ½"–1½"



No. 21, Lever Type
Sizes 2"–16"

PRESSURE REDUCING VALVES FOR HEATING SYSTEMS

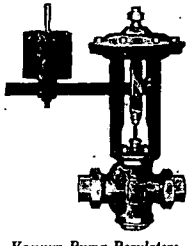


Vacuum Regulating Valve
Sizes ½"–4"

For regulating the amount of vacuum on separate branches of a main vacuum system.

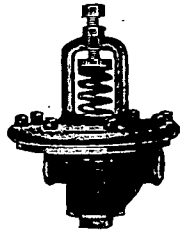
The new **Mason** Reducing Valves for heating systems are rapidly attaining the same popularity as the well known **Mason** high pressure reducing valves so widely used industrially.

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.**



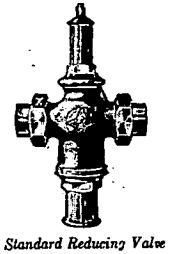
Vacuum Pump Regulators
Sizes ½"–4"

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.



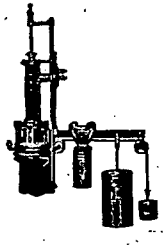
Household Water Pressure Regulator
Sizes ½"–1"

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.

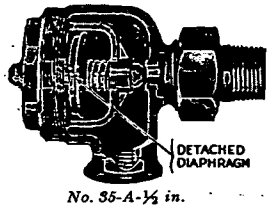
CATALOG—Write for Pocket Catalog and Handbook No. 62. It contains complete information about these and other **Mason** Regulators.

Monash-Younker Co., Inc.

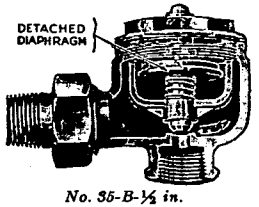
ESTABLISHED 1900

CHICAGO NEW YORK

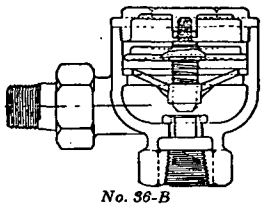
MONASH THERMOSTATIC RETURN LINE TRAPS



No. 35-A-½ in.



No. 35-B-½ in.



No. 36-B

The distinctive feature of the MONASH Thermostatic Line of Traps, is the *Diaphragm*, a separate and independent unit, so constructed and so held in place that friction and strain on the *Diaphragm* is reduced to a minimum: overcoming the hazard of fracture and rupture of the *Diaphragm*.

The No. 35-A has a vertical seat with the *Diaphragm* out of the Steam Chamber, while the No. 35-B is built with a horizontal seat and the *Diaphragm* in the Steam Chamber. These Traps are ½ in. pipe size, capacity 200 sq. ft., 65 lb. of water per hour.

MONASH No. 36-B Traps—As illustrated, is built with a diaphragm *in the steam chamber* and in the following sizes: Guaranteed for 10 lbs. pressure.

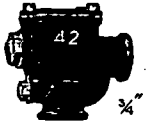
No. 36-B—½ in. pipe size; capacity, 350 sq. ft.; 108 lb. water per hour, in angle only.
No. 36-B—¾ in. pipe size; capacity, 500 sq ft.; 160 lb. water per hour, in angle only.
No. 36-BX—¾ in. pipe size; capacity, 1000 sq. ft.; 350 lb. water per hour, in angle only.

Monash Thermostatic Heavy Duty or Drip Traps for 25 lbs. Pressure

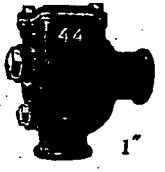
MONASH thermostatic special heavy duty or drip traps are made with dirt-pocket, clean-out and by-pass. Vertical seat and diaphragm outside the steam chamber. Especially suitable for **blast coils, dry kiln coils, main drips, dryers, laundry machinery** and all points where large quantities of condensation is to be handled.



½"



¾"



1"

No.	40	42	44
Size.....inches	½	¾	1
Sq. Ft. of Radiation.....	350	1500	5000
Water per Hour.....pounds	108	475	1560
Net Weight.....pounds	3.25	5.00	7.50

Monash Guaranteed Automatic Air Valves

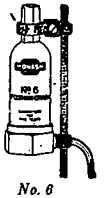


No. 1

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.

Specify MONASH Valve holder with valve.



No. 6

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 ⅛x¼ in., the No. 3 is ¼x⅜ in. 1 lb. net weight.



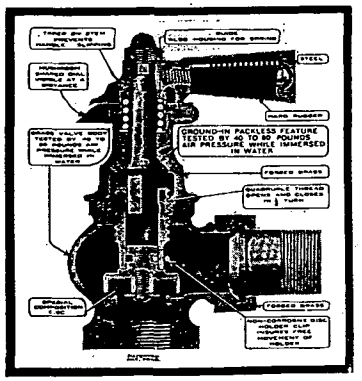
No. 2

O-E Specialty Mfg. Co.

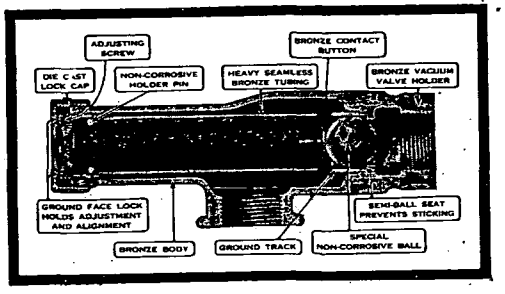
5-7-9 Keefe Ave., MILWAUKEE, WIS.

Packless Graduated Valves, Ball-Check Return Elbows, Thermo-Nickel Return Traps, Air Exhausters, Vacuum Valves, Vacuum Pressure Gages, Differential Return Traps and Balanced Swing Check Valves.

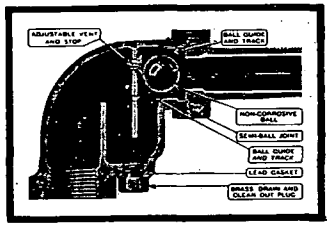
The operation of the **"O-E" Perfect Vapor Vacuum-Pressure System** is very simple: vapor generated at boiler passes up through main supply pipe and is admitted to radiator at top through the "O-E" Packless Graduated Valve. Water of condensation is returned to boiler through a ½-in. "O-E" Elbow. In passing through the Elbow the water is first trapped by means of a wall or diaphragm cast in the Elbow, *outside of the radiator*, making a water seal which holds the vapor in radiator and prevents it from short circuiting into the return main. Should the Supply Valve of radiator be closed and condensation form a vacuum any water that might be in the return pipes is prevented from returning to radiator by the "O-E" Patent Elbow, which is equipped with a small brass ball operating on a smooth guide or track, and so arranged that when a vacuum takes place in radiator ball will immediately roll against port and close it. Elbow is noiseless in operation, as water seal is below ball, which is an important feature. As soon as Supply Valve is again opened ball rolls off of seat allowing condensation and air to pass easily and freely into return main.



The "O-E" Improved Perfect Packless Graduated Valve is *absolutely packless* and never requires packing. It is tested by air and water test before shipment. It is quick opening, little more than one-half turn fully opens or closes it. Sand blasted and nickel plated. The handle being made of hard rubber, will not crack and is always cool and easy to operate. The graduated dial and pointer admit of partial opening so that just the amount of heat desired can be obtained. All valves are fitted with composition disc on a swivel seat without extra charge. Graduated Supply Disc will be attached when specified, at slight additional cost.



An air vent is tapped in the slot of the screw stop in the return elbow which not only allows air to escape freely into return system when Supply Valve is open, but also equalizes the pressure on both sides of Water Seal, thus preventing it from syphoning out, which it might otherwise do. All air and condensation pass through main return pipe in basement to a point above boiler where air is separated from water by means of "O-E" Patent *Air Exhauster* and *Vacuum Valve*.



The "O-E" Perfect Ball-Check Water Seal Union Elbow with Adjustable Air Vent is made in two sizes, ½-in. Capacity 250 sq. ft. ¾-in. Capacity 500 sq. ft.

The "O-E" Improved Air Exhauster and Vacuum Valve is simple and very sensitive, operating as follows:

Being connected at a high point above where the return main enters boiler, all air in the system seeks outlet at the Air Exhauster, which is open when there is any air in the system, and as soon as all air is exhausted and heat comes in contact with the Expansion Member in Exhauster, same expands and forces the Special Bronze Ball against the seat, closing the port. When closed system will cool slightly causing a vacuum which will hold ball on seat. As soon as vacuum is lost ball will roll away from seat and permit air to escape freely and quickly. The Improved cap locks the expansion post after it is properly adjusted and also holds post in a rigid horizontal position. All Exhausters are set for ordinary use, but can be adjusted to suit any particular system to which they are attached. All Exhausters are threaded for 1-in. I. P. both inlet and outlet.

Made in one size only, 1 in. x 1 in. Capacity 2,000 sq. ft.

We also announce the O-E Thermo-Nickel Return Trap, a combination thermostatic trap with a ball-check and many new features. Ask for descriptive bulletin and general catalog.

Stickle Steam Specialties Co.

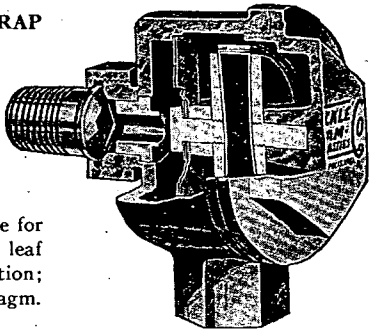
Main Office and Works, INDIANAPOLIS, IND.

NEW YORK OFFICE
48 E. 41st St.

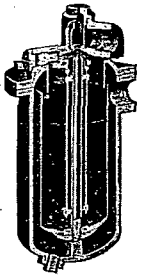
BOSTON OFFICE
52 Sudbury St.

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.

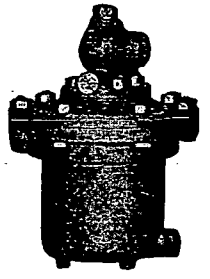
STICKLE THERMOSTATIC RADIATOR TRAP



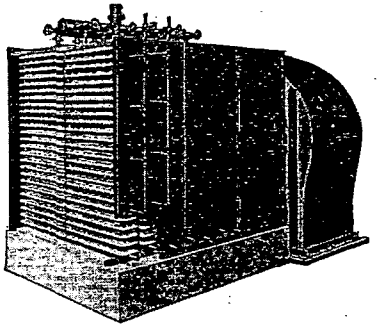
The special feature of the STICKLE Thermostatic Radiator Trap is the diaphragm; with box shape inverted heads, side walls reinforced with seamless drawn brass tubing, a solid disc protecting each head and so constructed that the diaphragm cannot get out of place. The diaphragm is so reinforced that there 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.

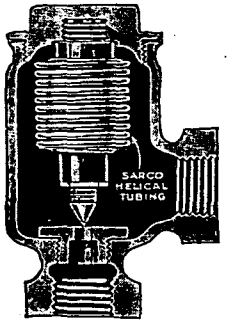
Write us regarding this heater. It has no equal. Cold air is heated and used, instead of using cooling water which goes to the sewer, the heat being lost.

Sarco Co., Inc.

183 Madison Ave., NEW YORK

BOSTON BUFFALO PHILADELPHIA CLEVELAND DETROIT CHICAGO

RADIATOR, BLAST AND STEAM TRAPS,
PACKLESS INLET VALVES, TEMPERATURE CONTROL AND STRAINERS



SARCO STEAM TRAP No. 9

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 lbs. **without readjustment.**

Has unusually great capacity, large valve area and quick, high lift when discharging. Closes instantaneously. No live steam can escape. Cannot air bind.

Small in size and low in price.

Write for Booklet No. 261.

List Prices F. O. B. Bethlehem, Pa.		Dimensions	Capacity
½"	$ 8.50	1¾" inlet to outlet	500 lbs. of water per hour
¾"	11.50	1¾" inlet to outlet	600 lbs. of water per hour
1"	14.50	2" inlet to outlet	800 lbs. of water per hour

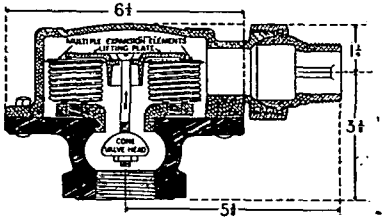
For Steam Pressure from 0 to 30 lbs. Type 9–1 can be used. It has the same capacities as Type 9–2 but is furnished with brass composition valve heads and seats at ½"–$7.50; ¾"–$10.50; 1"–$13.50 list.

SARCO HIGH AND LOW PRESSURE BLAST TRAPS

This Heavy-Service 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.



Section of 1¼" and 1½" No. 9-3

No. 9–3, PRESSURES 0–30 LBS.
Brass Composition Valve Head and Seat

List Prices F. O. B. Bethlehem, Pa.	Capacities Lbs. per Hour
1" $25.00	1,000
1¼" 27.50	1,000
1½" 30.00	1,500
2" 35.00	2,000

Can be furnished in offset patterns at same prices.

No. 9–4, PRESSURES 0–100 LBS.
Monel Valve Head and Seat

List Prices F. O. B. Bethlehem, Pa.	Capacities Lbs. per Hour
1" $30.00	1,250
1¼" 32.50	1,250
1½" 35.00	3,250
2" 42.50	5,000

Write for Blast Trap and Heavy Service Booklet.

SARCO TEMPERATURE REGULATOR

For hot-water service tanks, and cold storage plants; also for manufacturing purposes and dry room or kiln control. Write for Booklet No. 91.

SARCO SELF-CLEANING STRAINER

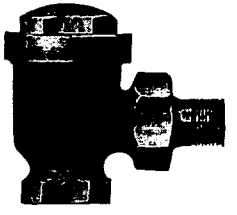
For Steam, water and oil lines. Write for Booklet No. 204

Sarco Co., Inc.

183 Madison Ave., NEW YORK

BOSTON BUFFALO PHILADELPHIA CLEVELAND DETROIT CHICAGO

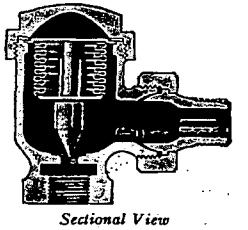
RADIATOR, BLAST AND STEAM TRAPS,
PACKLESS INLET VALVES, TEMPERATURE CONTROL AND STRAINERS



SARCO RADIATOR TRAP

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.

Helical Bellows is phosphor bronze. It has a high lift, insuring free discharge, a maximum closing pressure and an unusually long life.



Sectional View

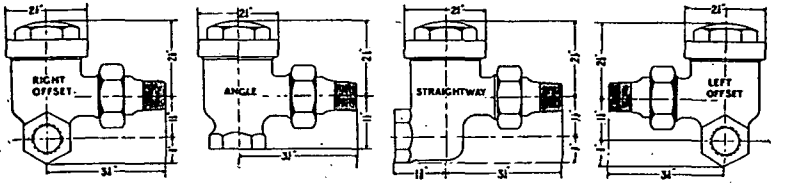
The motor element is not attached to the body and can be lifted out to wash out scale and dirt in new installations without affecting adjustment. Body is heavy brass, nickel plated.

Is factory adjusted and can be used on all pressures up to 25 lbs. without adjusting.

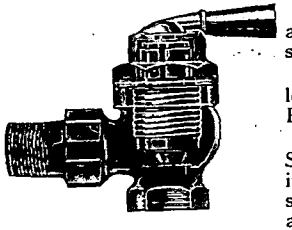
Write for Booklet No. 116.

List Prices F. O. B. Bethlehem, Pa.		Dimensions		CAPACITY—DIRECT RADIATION Vapor System	Vacuum System
½"	$ 6.00	A 3¼"	B 1½"	200 Sq. Ft.	250 Sq. Ft.
¾"	8.00	A 3¼"	B 1½"	600 Sq. Ft.	800 Sq. Ft.
1"	15.00	A 3⅝"	B 2"	1500 Sq. Ft.	1800 Sq. Ft.

Angle, straightway and offset types are furnished at same prices.



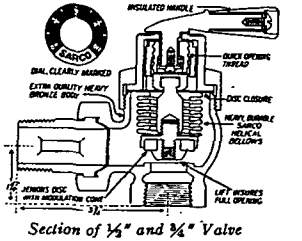
SARCO PACKLESS INLET VALVE



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.



Section of ½" and ¾" Valve

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 No. 151.

List Prices F. O. B. Bethlehem, Pa.		Center Inlet to Outlet	CAPACITIES Feet Direct Radiation
½"	$5.50	3¼"	up to 40 sq. ft.
¾"	6.00	3¼"	41 to 75 sq. ft.
1"	7.50	3¾"	76 to 125 sq. ft.
1¼"	9.50	4"	126 to 200 sq. ft.

TRANE HEATING SPECIALTIES

(See Trane Heat Cabinets on pages 394 and 395. Also Trane Pumps on pages 474 and 475.)

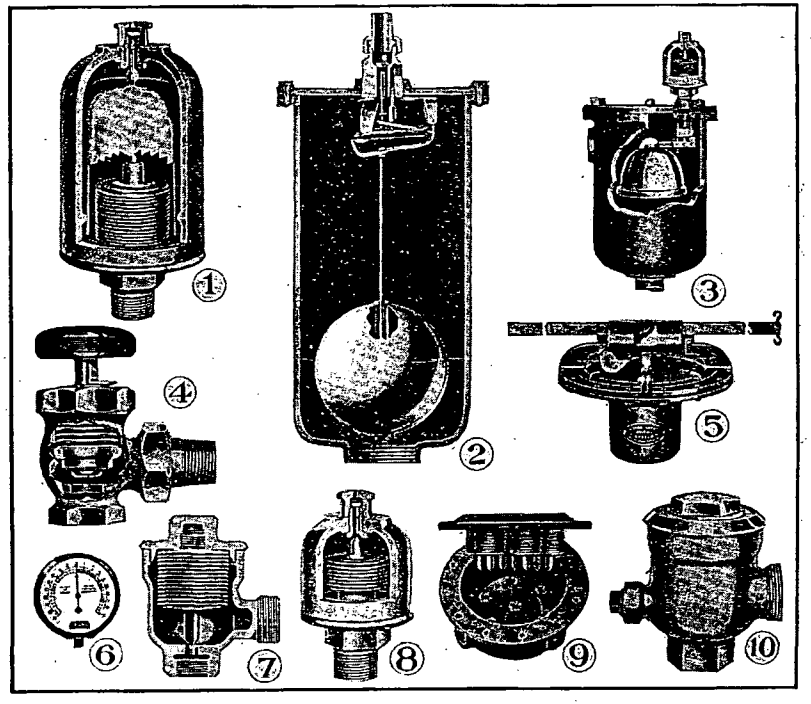
The Trane Company

La Crosse, Wis.

BRANCH OFFICES

New York, Chicago, Boston, Cincinnati, Newark, Philadelphia, Buffalo, Cleveland, Detroit, Seattle, Los Angeles, Albany, Minneapolis, Salt Lake City, Greensboro, N. C., Zanesville, Ohio, Tampa, Fla., Baltimore, Md., Des Moines, Iowa, New Haven, Conn., Sheboygan, Wis., Kansas City, Mo.; ENGLAND: 22-23 Clerkenwell Close, London, E. C. 1. CANADA: The Trane Co., 21-23 River St., Toronto, 2; Thomas Robertson & Co.; 134 Craig St., West, Montreal, F. S. Murdoch, 310 Breadalbane, Winnipeg; A. B. Madden, 48 Sparks St., Ottawa. JAPAN: Mitsubishi Shoji Kaisha, Ltd., Tokyo. CHINA: C. J. Doughty & Co., 8-9-10 Brenan Road, Shanghai.

The Trane Systems of Vapor and Vacuum Heating, Patented Heating Specialties, Trane Heat Cabinets, and Trane Automatic Electric Pumps, For All Purposes



TRANE HEATING SPECIALTIES

No. 1 Trane Float Vent Valve vents air but closes tightly against steam and water. Capacity unlimited for practical purposes. Full ¼ in. venting ports. ¾ inch pipe connection only. Weight 4 lb. Contains genuine Trane bellows.

No. 2 Trane Direct Return Traps and broken boilers are never found on the same vapor heating or straight steam job: Two sizes: 2,000 and 4,000 sq. ft. Multiples used for larger requirements.

No. 3 Trane Heavy Duty Float Vent Valves have an enormous venting capacity. They are used on extra large wet mains and are designed to quickly eliminate air, but to seal tightly against water, steam, and vacuum.

No. 4 Trane Bellows Packless Valves are packless in every respect. Contain genuine Trane bellows. Brass body. Nickled, highly polished trimmings. Practically indestructible handle. Especially designed as companion product for use with Trane Bellows Traps (No. 7) in connection with Trane Vacuum Pumps. (See Trane Pumps in Pump section of this Guide). Valves furnished in ½ in., ¾ in., 1 in. and 1¼ in. sizes.

No. 5 Trane Vapor Regulators are sensitive to ounces pressure instead of pounds. Two grades, Sensitive and Extra Sensitive, known as Size 1 and Size 2.

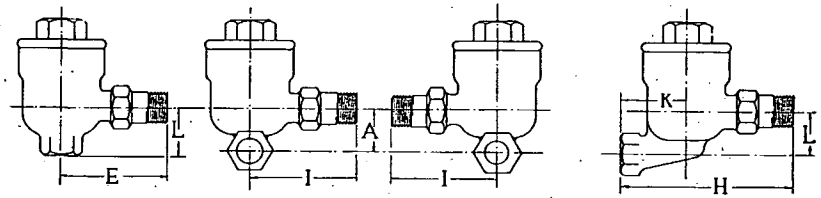
No. 6 Trane Pressure-Vacuum Gauges register to 30 lb. pressure and 18 in. vacuum. Also furnished to register to 30 in. vacuum only over entire scale. 4½-in. face. ¼-in. pipe connection.

No. 7 Trane Bellows-Type Radiator Traps have 14 corrugation bellows. These bellows are made without seams or joints of any kind. Trap bodies are made of steam brass. Sizes and styles are as listed below. Guaranteed range is from 15 in. vacuum to 25 lb. pressure without adjustment of any kind. These same traps are also available for high pressure service up to and including 125 lb.

No. 8 Trane Quick Vent Valves do the work of Float Vent Valves (see No. 1), except that they are designed to close against steam only. ¾-in. pipe connection. Contain Genuine Trane bellows.

No. 9 Trane Heavy Duty Blast Traps take the place of the bulky steam trap. They are used on blast coils and on large steam mains where a large amount of condensation is encountered.

No. 10 Trane 1-in. Bellows Trap specified for Drip or Blast Trap service. Made with ½-in. bypass as illustrated. Capacity at 1 lb. pressure difference is 1700 sq. ft. equivalent direct radiation. At 25 pounds, 8500 sq. ft. For large capacities use Trane 1¼ in. or 1½ in. Heavy Duty Blast Traps.



Angle *R. H. Corner* *L. H. Corner* *Straightway*

SIZES, CAPACITIES, ETC., OF TRANE RADIATOR TRAPS

Style	Size Inches	Capacity in Sq. Ft. at Various Pressure Differences				DIMENSIONS, INCHES					
		4 oz.	8 oz.	1 lb.	2 lb.	A	E	L	H	I	K
No. B2	½	125	175	245	344	1 3/32	3¼	1 7/16	5⅛	3¼	1⅞
No. B3	¾	375	525	735	1030	1 3/32	3¼	1 7/16	5⅛	3¼	1⅞
No. B4*	1	750	1050	1700	2200	...	3 9/16	1 23/32	...	...	...

*Made in angle pattern only. **Write for information on Trane 1¼" large capacity traps.**
Sizes conform to recommendations of *Heating and Piping Contractors' National Association.*

ESTABLISHED 1888

WARREN WEBSTER & COMPANY

Pioneers of the Vacuum System of Steam Heating

Camden, N. J. **50 Branch Offices**

Manufacturers of Webster Systems of Steam Heating and Webster System Equipment—More Than 37,000 Installations—Also Webster Feed Water Heaters of Genuine Puddled Wrought Iron

Webster Products

WEBSTER VACUUM AND MODULATION SYSTEMS OF STEAM HEATING.

WEBSTER SYSTEM APPARATUS: Including Sylphon Traps; Diaphragm (No. 7) Traps; Modulation Supply Valves; Sylphon Quick-opening Packless Valves; Dirt Strainers; 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 Tank, Feed-Water Heaters, Webster-Lea Heater-Meters, Steam and Oil Separators.

Webster Service

Is an integral part of every Webster System delivered through 50 branch offices. Webster Service places the accurate, comprehensive information resulting from the extensive experience of this organization at the disposal of heating engineers, architects and heating contractors.

Webster Service in printed form includes STEAM HEATING, a useful manual of design; SERVICE DETAILS, a loose-leaf service showing correct connections and saving a substantial amount of the designer's time; CATALOGUE BULLETINS describing Webster apparatus from the standpoint of the engineer.

Webster Vacuum Systems

Operate on exhaust or live steam at very low pressure. Used with direct radiation or in combination with blast coils or unit heaters. Particularly suited for large buildings or where process steam is used.

Webster Type "R" Modulation Systems

A low pressure steam heating system suitable for all types of buildings having little or no demand for process steam and a basement or other means for placing low pressure boiler *below* the lowest radiator. For installations from 500 to 32,000 sq. ft. of equivalent direct cast iron radiation. Can be operated safely and satisfactorily by unskilled labor.

Operation:—Steam pressure is controlled by the sensitive Webster Damper Regulator. Steam is admitted to radiators thru Webster Modulation Valves or Webster Sylphon Valves. Condensation and air are freely discharged past Webster Return Traps which close on contact with steam, thus avoiding waste. Air and condensation are carried to the basement apparatus consisting of the Webster Boiler Return Trap and Vent Trap in combination. All air escapes thru the Webster Vent Valve. The Webster Boiler Return Trap provides positive equalization of pressure assuring return of water to boiler.

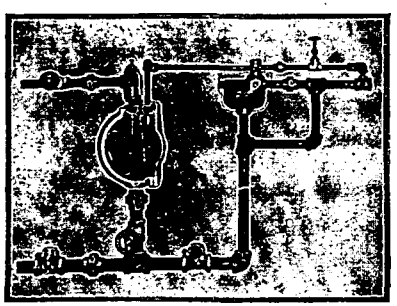


Fig. 1. Webster Type "R" System Basement Equipment

Webster Sylphon Packless Quick-opening Supply Valves

Open with less than a turn of lever or wheel handle. Positively packless, having flexible laminated Sylphon bellows completely enclosing stem. Body of steam brass, composition disc, hard rubber handle. Made in ½ to 1½-in. sizes. Ask for Bulletin 705-51.

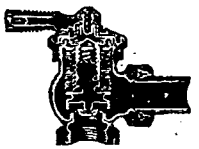


Fig. 2. Webster Sylphon Packless Quick-Opening Valve

Webster Modulation Supply Valves

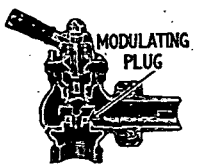


Fig. 3. Webster Modulation Supply Valve

Provide by means of the tapered modulating plug, close heat control of each radiator. Particularly well-suited for residence heating systems, as it permits heating any desired portion of radiator. Sizes, ½ to 1¼ in. Ask for Bulletin 705-3.

Webster Sylphon Traps

Effectively discharge all condensation and entrained air from radiators or coils without permitting passage of steam. Operation is by means of a sensitive volatile liquid contained in a rugged Sylphon bellows. Factory adjusted, and made in sizes from ½ to 1¼ in. Ask for Bulletin 701.

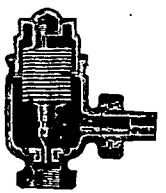


Fig. 4. Webster Sylphon Trap

Webster High Pressure Traps

Webster No. 78 series Thermostatic Traps provide an effective means for draining condensation and air under high pressure conditions. Made in two classes for service up to 100 lbs. per sq. in. The cooperation of the Webster Sales Engineering organization is extended to all those having high pressure drainage problems.

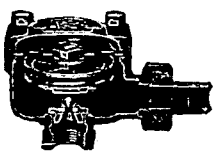


Fig. 5. Webster High Pressure Trap, No. 78 Series

CoKal Stoker Corporation

1010 Wrigley Building, CHICAGO, ILL.

Combustion Engineers

Representatives in

BUFFALO KANSAS CITY NEW YORK CITY PHILADELPHIA PITTSBURGH ST. LOUIS

and in all Principal Cities

PRODUCTS

CoKal Plain Hand Fired Stoker.

CoKal Hopper Feed Stoker.

CoKal Power Feed Stoker.

CoKal CombustiKator for Low Pressure Boilers.

CoKal Pulverzone

Also CoKal Hang-over Arch for H. R. T. Boilers; all standard types of Boiler Arches.

The "PULVERZONE" undoubtedly represents the ideal method of burning coal, for it burns the fines in suspension and spreads the larger particles of coal according to their weight over the entire grate area. Smokeless at all loads, it meets the strictest smoke ordinances.

A blast passes through the curtain of coal, carrying the fines into the furnace space where they ignite in suspension. Eight nozzles are arranged so that turbulence before, at and after ignition causes intimate mixing of air and volatile with very high combustion efficiency and full utilization of furnace volume in consequence. By distributing coal particles over fuel bed according to their weight, the coarser coal dropping down directly in the coking zone at front while the lighter pieces pass toward the rear, a porous fuel bed of low resistance to air supply is obtained while holes in fire are prevented. Intensive combustion rates with low draft become possible. Hand cleaning is eliminated.

The PULVERZONE combines the three most approved methods of burning coal:

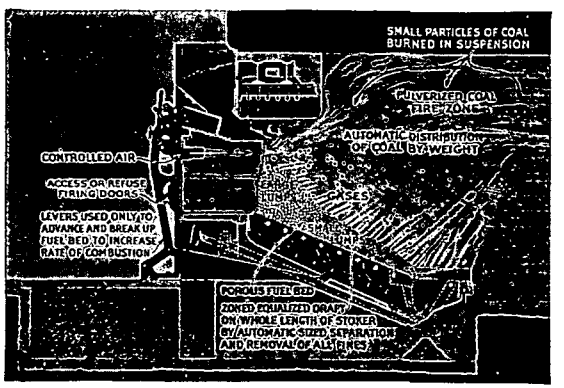
1—PULVERIZED COAL BURNING
Instantaneous ignition of the fine particles in suspension without danger of explosion.

2—SPREAD METHOD
(Light and Continuous) by automatically separating, grading and distributing of coal sizes by weight.

3—COKING METHOD
The Standard CoKal Stoker fuel bed provides the intense heat necessary for burning the fines and the spread coal.

The outstanding features of the PULVERZONE are—smokelessness; high efficiencies; quick response to load changes; large overloads; perfect combustion using standard screenings (wet or dry); no slagging; eliminates cleaning periods.

The PULVERZONE is suitable for all boilers from 100 to 2000 boiler horsepower. The CombustiKator is ideal for boilers of the Kewanee firebox type. Ask for full particulars about the five types of CoKal coal burning equipment.



PULVERZONE showing "turbulence before, at and after ignition" and general arrangement of fuel bed

RILEY STOKER CORPORATION

"RILEY" Underfeed Stokers | "JONES" Underfeed Stokers | "HARRINGTON" Traveling Grate Stokers

"MURPHY" Automatic Furnaces | Pulverized Coal Installations

9 Neponset Street, WORCESTER, MASS., U. S. A.

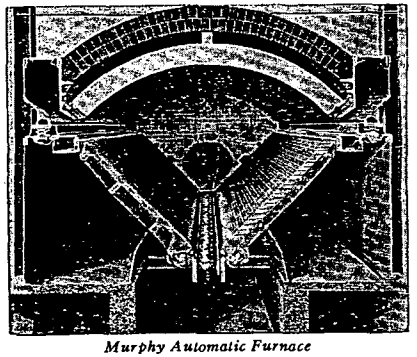
BOSTON NEW YORK PHILADELPHIA PITTSBURGH BUFFALO CLEVELAND DETROIT
CINCINNATI CHICAGO ST PAUL KANSAS CITY DENVER CHARLOTTE DALLAS

Riley Engineering and Supply Co., Ltd., Toronto

COMBUSTION EQUIPMENT FOR EVERY NEED

Riley Stoker Corporation manufactures Riley Multiple-Retort Stokers, Jones Side Dump, Lateral Retort and Standard Stokers, Harrington Traveling Grate Stokers, Murphy Automatic Furnaces, and the Atrita Unit Pulverizer. These stokers are suitable for different types of boilers and can take care of large or small boilers burning anthracite coal, coke breeze, Eastern bituminous, Pittsburgh, Illinois, Indiana, Iowa coals and lignites.

Write for catalogues covering each of these types for your reference files.



Murphy Automatic Furnace

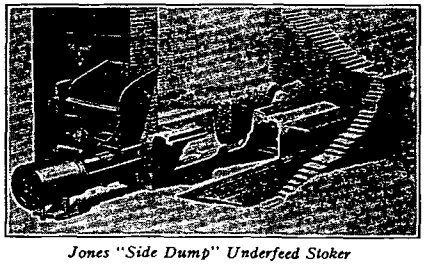
MURPHY AUTOMATIC FURNACE

The Murphy Automatic Furnace is of the overfeed, natural draft type and is particularly adapted for use in office buildings, hotels and schools. It saves 15 to 25 per cent over hand-fired methods, it saves labor, it is smokeless in operation, it does not emit gases to circulate up through the building. All ash and refuse are removed automatically. This means a clean fire and high efficiency at all times. The Murphy Furnace does away with the necessity of opening fire doors and thereby eliminates the admission of cold air. The coal supply for the furnace is under absolute control and automatic regulation. It is a natural draft furnace and requires no fan or blower equipment.

JONES SIDE DUMP UNDERFEED STOKER

The Jones Side Dump Stoker is of the forced draft, underfeed type and is very widely used for both heating and power loads in all types of buildings thruout the country. It is of the side cleaning type, ashes being dropped into a shallow ashpit, permitting easy removal. Only slight excavation is required for the two shallow ashpits, therefore the installation cost is low. The stoker gives high efficiency and responds very quickly to load demands. It has a fuel burning capacity of 1200 to 1800 lbs. of coal per hour. This stoker is made in steam driven type and also mechanically driven type.

Where bigger boilers are used Riley Stokers, Harrington Traveling Grate Stokers, Atrita Unit Pulverizers and Lateral Retort Stokers can be used.



Jones "Side Dump" Underfeed Stoker

THE DEPENDABILITY AND ECONOMICAL OPERATION OF RILEY STOKER CORPORATION EQUIPMENT PARTICULARLY ADAPTS IT TO HEATING REQUIREMENTS

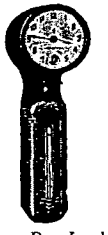
A few well-known Installations

NEIL HOUSE, Columbus, Ohio
BLACKSTONE HOTEL, Chicago, Ill.
SEVENTY-SIX SCHOOLS IN Detroit, Mich.
MAXWELL HOUSE, Nashville, Tenn.
UNIVERSITY OF Chicago, Ill.
SIXTEEN SCHOOLS IN Buffalo, N. Y.
DETROIT MASONIC TEMPLE, Detroit, Mich.
UNION CENTRAL LIFE BLDG., Cincinnati, Ohio
STATLER HOTEL, Detroit, Mich.
NEW WILLARD HOTEL, Washington, D. C.
GIBSON HOTEL, Cincinnati, Ohio
PHOENIX HOTEL, Lexington, Ky.
THIRTY-THREE SCHOOLS IN Cleveland, Ohio
INTERSOUTHERN LIFE BLDG., Louisville, Ky.
SYRACUSE HOTEL, Syracuse, N. Y.
OHIO MASONIC HOME, Springfield, Ohio
WADE PARK MANOR, Cleveland, Ohio
HAMM BLDG., St. Paul, Minn.
HIGHLAND HOSPITAL, Rochester, N. Y.
CHICAGO & NORTHWESTERN BLDG., Chicago., Ill.

Honeywell Heating Specialties Company

Wabash, Indiana

Manufacturers of Honeywell Temperature Regulators for Residential or other Heating Plants—Hot Water, Vapor, Steam, or Hot Air.



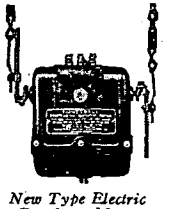
Fifteen-Day Jeweled Balanced Clock Thermostat



Plain Pattern Thermostat



Wall Plate Used on All Honeywell Thermostats



New Type Electric Regulator Motor

The HONEYWELL Temperature Regulator is an automatic device which opens and closes the dampers of the heater (any type) whenever the room temperature varies one degree from that for which the Regulator is set.

The HONEYWELL Temperature Regulator has but two parts, the thermostat and the motor. The thermostat is placed on an inside wall at some central location and electrically controls the operation of the motor, which is located near and connected to the heater.

The automatic regulation so effected insures a constant temperature, day and night, minimum fuel consumption and maximum comfort and health. The cost of operation, even with the electric motor models, is negligible.

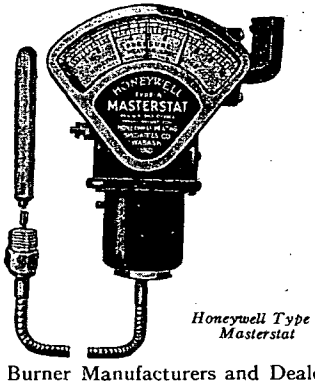
The exclusive HONEYWELL Wall Plate is standard with all HONEYWELL Thermostats. Its use simplifies installation to such a point that the novice mechanic finds it easy.

The Regulator is made in three types, Gravity Motor, Spring Motor, and Electric Motor; and nine models, three of each type. The first model of each type is equipped with plain thermostat, requiring manual adjustment for day and night temperatures. The second model of each type is equipped with one-day clock pattern thermostat which automatically brings the room temperature to the degree for which the Regulator is set, at any predetermined hour. The third model of each type is equipped with 15-day automatic clock thermostat which automatically regulates both the day and night temperatures, at any predetermined degree and hour, without manual adjustment of any kind.

LIST PRICES—(Subject to Discount)

TYPE DR, Electric Motor—15-Day Jeweled Clock Thermostat	$80.00
TYPE DS, Electric Motor—One-Day Clock Thermostat	77.00
TYPE DQ, Electric Motor—Plain Thermostat	70.00
TYPE SR, Spring Motor—15-Day Jeweled Clock Thermostat	65.00
TYPE SS, Spring Motor—One-Day Clock Thermostat	52.00
TYPE SQ, Spring Motor—Plain Thermostat	45.00
TYPE GR, Gravity Motor—15-Day Jeweled Clock Thermostat	58.00
TYPE GS, Gravity Motor—One-Day Clock Thermostat	45.00
TYPE GQ, Gravity Motor—Plain Thermostat	37.00

(Above prices include necessary installation materials).



Honeywell Type A Masterstat

Oil Burner Manufacturers and Dealers have long felt the need of and will appreciate such a device as the HONEYWELL Type A Masterstat.

Designed for use with the intermittent type oil burner, it is a safe means against firing a dry boiler and in addition limits the pressure or temperature of the heating plant to the desired point.

The Masterstat is applicable to steam, vapor, vacuum, hot water or warm air systems.

Details will be supplied upon request.

Johnson Service Company

Milwaukee, Wis.

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PITTSBURGH, PA., 10 E. North Diamond St., N. S.
PORTLAND, ORE., 404 Failing Building
SALT LAKE CITY, UTAH, 610 McIntyre Bldg.
SAN FRANCISCO, CAL., 417 Rialto Building
SEATTLE, WASH., 473 Colman Building
ST. LOUIS, MO., 14 North Twelfth Street
GREENSBORO, N. C., Daily News Building, P. O. Box No. 617

CANADIAN REPRESENTATIVE

Johnson Temperature Regulating Company of Canada, Limited

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VANCOUVER, B. C., 550-6th Avenue, West
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WINNIPEG, MAN., 259 Stanley Street
MONTREAL, 119 Youville Square

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 TEMPERATURES 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.

Specific Applications of Temperature Control

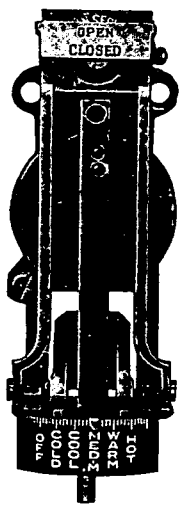
Bake ovens for enamels, japans, etc.
Core drying ovens.
Drying room for paint, varnish, patent leather, etc.
Storage room for tobacco, rubber or similar goods.
Cold storage rooms, fur vaults, etc.
Canning machinery, cookers, exhausters, processors.
Corn and oats drying apparatus.
Fruit drying apparatus.

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 exquisitly made and thoroughly tested for accuracy, efficiency and durability.

Johnson Positive Thermostat

Has a snap action for closing and opening valves quickly, positively and fully, thereby assuring their durable and satisfactory operation. Has an indicator showing at a glance whether the heat is "ON" or "OFF." Has a convenient means for shutting off the heat when desired.



Model Positive Metal Diaphragm Thermostat

Johnson Intermediate Thermostat

Has all-metal movement, giving true graduated motion to mixing dampers for "Blast Heating Systems" and, where desirable, can be used to operate steam valves on a "Vacuum Heating System."

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

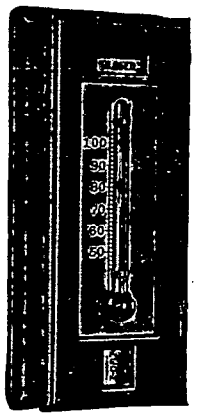
The Dual, or two-temperature Thermostat provides for a daytime temperature (usually 70°) and a night-time temperature (35° to 50°), as desired, for all or some of the rooms in a building, simply by the manipulation of a single push button by the engineer or other person in authority. It is a factor for 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

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.



Model R. I. Cover 4¾"x2"x1⅛" deep

The P type is a pressed metal cover, very finely finished but not as orna-

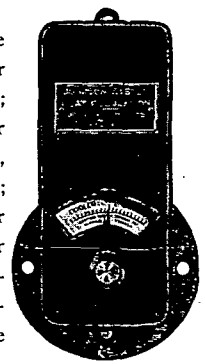
mental and artistic as the R cover, and used more generally in schools, office buildings, hospitals and places where simple and neat design is desired rather than artistic and ornamental.

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.

This thermostat is made either positive or graduated acting.

Applications



Pneumatic Insertion Thermostat

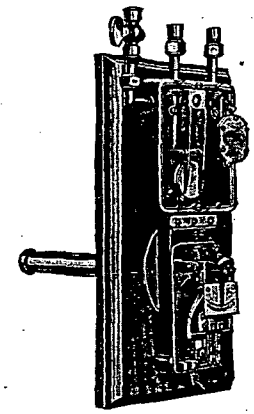
Adaptable for use in bake ovens for enamels, japans, etc.; drying rooms for paints, varnishes, patent leather, etc.; storage rooms for tobacco, rubber or similar goods; sterilizers or pasteurizers; cold storage rooms, fur vaults, etc.; refrigerator machine control; humidity control for air washers; flue gas temperature control; hot blast heating plants; combination tempered ventilation and hot blast systems; greenhouses, turkish bath rooms, etc.; tempered ventilation for buildings.

Johnson Calibrated Thermostat

This is an especially high grade insertion thermostat for use where it is desired to change frequently the adjustment to operate at different temperatures. It is operated by compressed air at 15 lb. per sq. in., and used to control temperatures of liquids and air by automatically opening and closing a diaphragm valve or damper. Graduations made to meet requirements, limited to a total range of 60 deg.

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 made to work with positive action when controlling valves; with graduated action when controlling dampers; or with both positive and graduated action when controlling valves and dampers.



Multiple Insertion Thermostat

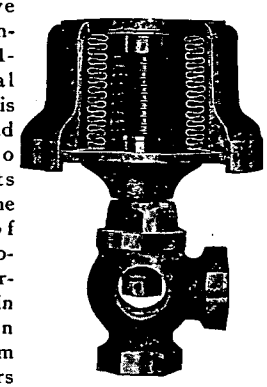
Tank Thermostat

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.

"Sylphon" Metal Diaphragm Valves



"Sylphon" Metal Diaphragm Valve

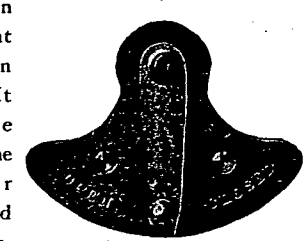
This valve having an indestructible 1-piece metal diaphragm, is permanent and requires no repairs. Its value for the control of steam is obvious and particularly so in connection with steam coils, radiators in wall boxes where excessive heat would destroy rubber diaphragms.

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.

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 a complete system of automatic temperature regulation and humidity control, furnishing all necessary thermostats, valves, dampers, humidifiers, special devices, air compressors, piping and fittings, and labor of installing system, except setting valves and dampers in position—all in accordance with the following schedule and detailed specification:

SCHEDULE—State the rooms to be controlled and number of thermostats in each; the manner in which the tempered air, if there is any, is to be controlled; the manner in which the drafts of the boiler are to be controlled; and specify the manner of the control of any fresh air, vent or return air dampers, stating the location and number of switches.

THERMOSTATS—Where the greatest economy of fuel and the most flexible handling of the heating system is desired specify the Johnson Dual or Two-Temperature thermostat and that it shall operate at all times at one set pressure not less than 15 lbs. per square inch. If dual thermostats are not desired specify Johnson Metal Diaphragm Model Thermostat, size, 4½ x 2 x 1 in.; and state whether it is to have residence or school cover, indicating device, positive shut-off, and whether it is to be positive or intermediate motion. Specify the number and kind of inserted thermostats.

VALVES—Specify Johnson Metal Diaphragm Valve having the "Sylphon" Metal Bellows for its diaphragm. State whether valves are to be plain or nickel-plated *with or without unions*; add: Valves to be placed in position by heating contractor.

AIR COMPRESSORS—Specify kind of air compressor (steam, hydraulic, electric or power driven), requiring that the air compressor shall be of sufficient size to operate the system, with a factor of safety not less than 3, and requiring that it be provided with all necessary governing devices, fittings, gage, etc.

HUMIDOSTATS—Specify Johnson Humidostat and Humidifier, stating the kind of humidifier, whether perforated steam or copper evaporating pan.

DAMPERS—Specify that dampers shall be made by the heat regulating contractor, but installed by the galvanized iron contractor, and that dampers shall consist of wrought iron frames, sheet steel blades, strongly cleated, with brass bearings.

GUARANTEE—Require that system be complete in every respect, and that all necessary material and special fittings shall be furnished whether specifically mentioned or not. Require that entire system be guaranteed free from all original defects in material and workmanship, and that any parts proving defective or *wearing out within 2 years from date of* completion shall be replaced free of charge. Require that thermostats shall operate the valves or dampers to which they are attached, at a variation of not to exceed 1 deg. above or below any given point.

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.

Minneapolis Heat Regulator Company

Main Office—MINNEAPOLIS, MINN.

Service Branches in Principal Cities

MANUFACTURERS OF TEMPERATURE CONTROL DEVICES

The standard line of Minneapolis Heat Regulators is for use in dwellings and buildings of all kinds, using fuel and heating plants of every type except power oil burners, which require the use of Minneapolis Series Ten Controls. All Minneapolis controls operate on a one degree change of temperature.

FOR DWELLINGS

The standard equipment for use in dwellings is the Minneapolis thermostat, equipped with either a one-day clock, or the eight-day, seven-jewel clock; the motor for operating the draft and check; and the limit control, which operates independently of the room thermostat and acts as a secondary control and safety device.

FOR APARTMENTS AND LARGE BUILDINGS

The same equipment as described for use in dwellings is used in larger buildings and gives thoroughly satisfactory service in buildings of from ten to twelve stories or more.

CENTRAL PLANT STEAM

Where buildings are heated with central plant steam, a Minneapolis thermostat, equipped with either the one-day clock or the eight-day, seven-jewel clock, is almost invariably used. It controls the operation of the motor, which opens and closes the steam valve.

FOR OIL BURNERS

For oil burners, there are special controls known as the Minneapolis Series Ten. They include the Series 10 thermostats, relay, Protectostat, and Protectorelay and provide complete and unfailing control for every type of burner.

INDUSTRIAL USES

To control hot water boilers in residences, hotels, or large buildings; enamelling bake ovens, dry kilns; glue, chocolate or paraffin vats; refrigerating systems, etc.

DUAL CONTROL

The Model No. 65 and the Model No. 70 Limit Controls are used in connection with the thermostat. They operate independently of the thermostat, thus giving two sources of control, one working on the temperature at the heating plant and the other on the room temperature. They prevent over heating of the plant and building.

THERMOSTATS

These are made in several types: The Model No. 40, plain thermostat, no-clock; The Model No. 47, with one-day clock; No. 77 with eight-day, seven-jewel clock, with automatic day and night temperature change mechanism. These instruments are finely constructed, operate on a temperature change of one degree from the point at which they are set, and will last indefinitely. There is nothing to get out of order.

LIMIT CONTROLS

These controls are made in two types: The No. 65 is the temperature control for use on hot water heating plants, domestic hot water supply, industrial processes, steam or vacuum heating plants; standard scale is 100° to 240°; standard extension of the tube 2"; on special order instruments can be furnished with ranges up to 490° and extensions up to 24".

The Model No. 70 is the pressure control for use on steam and vapor plants. The standard range is 0 to 10 pounds, but can be furnished with scales ranging as high as 125 lbs.

MOTORS

Electric Motor: No. 24 A. C. requires no attention except occasional oiling; the transformer for supplying low voltage through the thermostat is built in. 6 volt D. C. motor is for use when 110 volt A. C. current is not available. It operates from four dry cells which will operate it for one full heating system. Spring Motor: Made to operate approximately one week with a single winding with normal use on coal burning domestic heating plants, equipped with safety switch so that in event of the motor being allowed to run down, the draft will always be left closed on the last operation of the motor. Gravity Motor: For use with domestic heating plants, using coal or coke as fuel; must be wound daily. It is equipped with a safety switch similar to that used on the spring motor.

Catalogs giving complete detailed information, including prices and trade discounts will be mailed free upon request.

THE POWERS REGULATOR CO.

36 years of specialization in temperature control

GENERAL OFFICES AND FACTORY
CHICAGO, ILL.
2719 GREENVIEW AVENUE

GENERAL EASTERN OFFICES
NEW YORK, N. Y.
126 EAST 44th STREET

BRANCHES AND SERVICE STATIONS

ATLANTA, GA.
BALTIMORE, MD.
BOSTON, MASS.
BUFFALO, N. Y.
BUTTE, MONT.
CHARLOTTE, N. C.
CHATTANOOGA, TENN.
CINCINNATI, OHIO
CLEVELAND, OHIO
DENVER, COLO.
DES MOINES, IOWA
DETROIT, MICH.
EL PASO, TEXAS
HOUSTON, TEXAS
INDIANAPOLIS, IND.
KANSAS CITY, MO.
LOS ANGELES, CALIF.
MILWAUKEE, WIS.
MINNEAPOLIS, MINN.
NASHVILLE, TENN.
NEW ORLEANS, LA.
PHILADELPHIA, PA.
PITTSBURGH, PA.
PROVIDENCE, R. I
ROCHESTER, N. Y.
ST. LOUIS, MO.
SAN FRANCISCO, CALIF.
SEATTLE, WASH.

THE CANADIAN POWERS REGULATOR CO., LTD., TORONTO, ONT.
BRANCHES
CALGARY, HALIFAX, MONTREAL, VANCOUVER, WINNIPEG (3306A)

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.

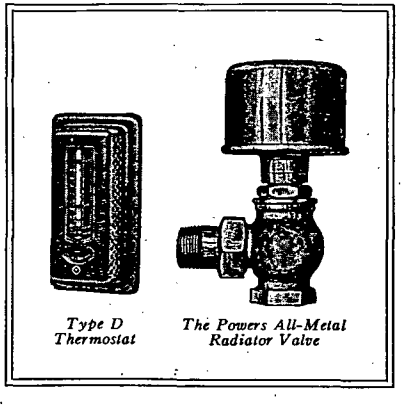
Automatic Regulators for ACCURATELY controlling temperature of Liquids, Gases and Air, Pressure Reducing Valves, High Pressure Steam Traps, Humidity Control Devices, Shower Mixing Valves, Etc.

Temperature Controlling Appliances

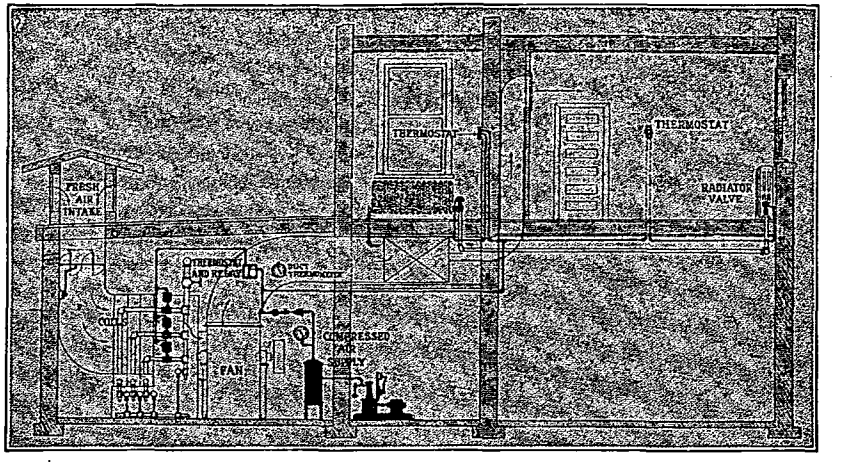
Powers thermostats are accurate in their working and will maintain their adjustment. They are of the vapor disc type, exclusive with Powers regulators, and are not thrown out of adjustment by extremes of temperature or long disuse. For over 35 years the accurate control obtained by this method has been 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.



Type D Thermostat — *The Powers All-Metal Radiator Valve*



Application of Powers Control to Combination (Split) System of Heating—Direct radiation supplies the heat; fan supplies warm air for ventilation. Thermostats control valves on radiators to maintain proper room temperature. Ventilating coils are controlled by a thermostat placed in the fan discharge duct.

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.

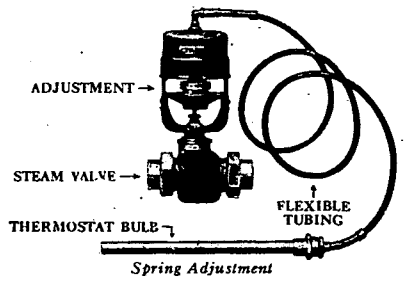
Prices

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.



Spring Adjustment

The Powers No. 11 Tank Regulator

Used on steam heated hot water service tanks in hotels, apartment buildings, offices, schools, shops, hospitals, factories, laundries, etc. Because this regulator prevents overheated water, it saves fuel and prolongs the life of valves and packings. Self-operating; easily installed. Of great durability, guaranteed accurate and positive in action.

In ordering, always give size of tank, steam pipe size, steam pressure, and temperature wanted.

The spring type regulator is commonly used for this work, except in sizes larger than 4-inch, when the lever type is used. Smaller sizes will be furnished in lever type if preferred.

The regulator will be furnished to operate at 160 deg. fahr., with adjustability 20 deg. above and below that point, unless otherwise specified.

Flexible connection tube is 6 ft. long for sizes 1½-inch and smaller; 8 ft. for 2-inch to 4-inch, inclusive; and 10 ft. for larger sizes. Additional lengths of tubing will be furnished at 30 cents net per ft. A net charge of $2.00 is made for flexible tubing shorter than standard.

Flanged valves will be drilled standard unless otherwise ordered.

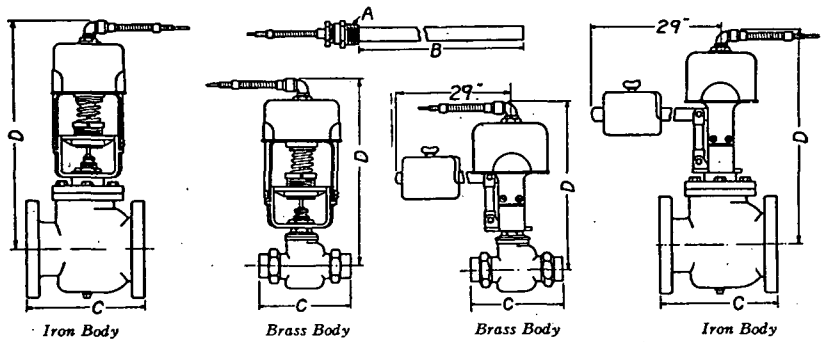
Specification

In connection with the (steam heated) hot water storage tank, furnish and install Powers No. 11 Tank Regulator with (..... inch) standard valve with standard length of flexible tubing. Regulator shall maintain the temperature of the water at (..... deg.) with steam pressure at (..... lbs.).

NOTE—Where installation is to control steam coil and auxiliary coal burning heater, specify No. 12 Regulator with chains, pulleys, etc., for the control of dampers on auxiliary heater (see Bulletin No. 129).

For coal burning heaters without steam coils, use Powers No. 13 Regulator (see Bulletin No. 136).

For Dimensions, Prices, etc., See Next Page

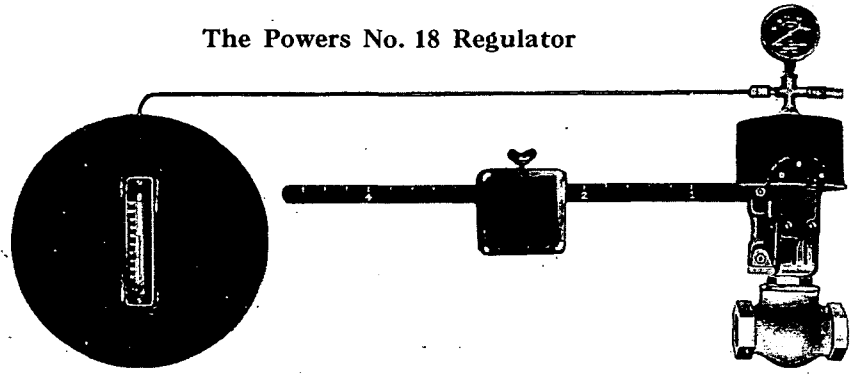


THE POWERS No. 11 TANK REGULATOR—Prices and Principal Dimensions

Valve Size ..... Inches	½	¾	1	1¼	1½	2	2½
List Price (Standard Valve)	$60	$65	$70	$75	$80	$90	$95
List Price (Monel Valve)	$70	$76	$82	$90	$98	$113	$122
Style of Body	Union	Union	Union	Union	Union	Screwed	Screwed
Material of Body	Brass	Brass	Brass	Brass	Brass	Iron	Iron
Dimension A ..... Inches	1	1	1	1	1	1	1
B ..... "	10	10	12	14	14	16	16
C ..... "	5⅝	6	6⅝	6⅞	7⅛	8	9
D ..... "	11	11⅛	11½	11⅝	12⅛	14⅜	15¼

Valve Size ..... Inches	3	3½	4	5	6	8
List Price (Standard Valve)	$100	$110	$120	$175	$225	$275
List Price (Monel Valve)	$130	$145	$160	.....	.....	.....
Style of Body	Screwed	Flanged	Flanged	Flanged	Flanged	Flanged
Material of Body	Iron	Iron	Iron	Iron	Iron	Iron
Dimension A ..... Inches	1	1	1	1¼	1¼	1¼
B ..... "	18	20	20	20	20	24
C ..... "	9½	10¾	10¾	12	13⅛	16⅛
D ..... "	15¼	15⅜	15⅜	21⅛	23	24

The Powers No. 18 Regulator



A Self-Operating Regulator for Control of Compartment Temperatures Between 60 Deg. and 100 Deg. Fahr.

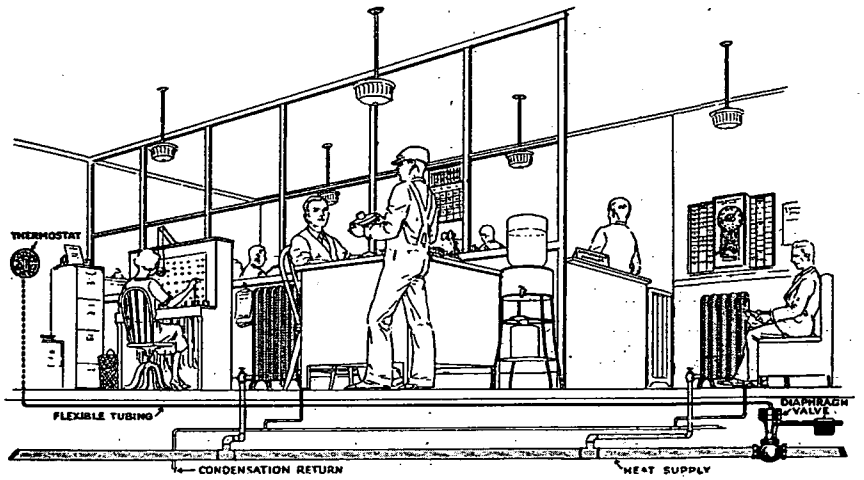
The Powers No. 18 Regulator shown above is a self-contained unit, not as sensitive in operation as the air pressure types but inexpensive and capable of good general control between the limits of 60 deg. and 100 deg. fahr., where such control can be obtained by the operation of a single valve regulating the heat supply. The control of this valve is gradual and an efficient return line vacuum system is essential.

This regulator is used in shops, offices, warehouses, storage rooms, low temperature drying rooms, small ventilating units, greenhouses, etc.

It is easy to install and is very DURABLE. Gives true gradual control. By changing the position of the adjusting weight, different temperatures over a 20 deg. fahr. range at the thermostat may be secured.

The flexible connecting tube may be of any length up to 75 feet or with the smaller valves 100 feet, and is usually of lead closely armored with galvanized steel wire. Armored copper tube can be furnished where conditions of vibration require its use, as in the control of fan ventilating units.

Standard flexible lead connecting tube of 50 feet will be sent unless otherwise specified; excess if any, can be coiled up near



Powers No. 18 Regulator applied to Direct Heating System

valve or damper motor. Additional tube length will be furnished at 20 cents net per foot.

For control of ventilating units or under other conditions of vibration, copper tube, armored, must be used instead of lead—such armored copper tube will be furnished at an extra net charge of 20 cents per foot for first 50 feet, and 30 cents per foot for excess.

Always specify desired operating temperature and steam pressure, and state whether latter is constant or fluctuating.

Bulletin 145 gives complete information.

PRICE LIST AND SHIPPING WEIGHTS OF No. 18 REGULATOR AND VALVE COMPLETE

Size	½"	¾"	1"	1¼"	1½"	2"	2½"	3"	3½"	4"
Price—Low Pressure....	$50	$55	$60	$65	$70					
Price—High Pressure...	60	65	70	75	80	$90	$125	$145	$175	$185
Shipping Weight (Lbs.).	45	48	50	55	60	65	110	120	160	170

No. 15 Regulator, self-contained, for the control of drying rooms, dry kilns, ovens, etc. Bulletin No. 138.

Dial Thermometers for air ducts and hot water tanks. Accurate, easy to read, reasonably priced. Bulletins No. 140 and No. 155.

High Pressure Steam Trap, ⅜ inch and ½ inch sizes only, for pressures from 5 lbs. to 125 lbs. Used on restaurant fixtures, hospital sterilizers, heating coils, cooking kettles, etc. Bigger capacity than any other trap its size. Acts quickly, closes tight. Gives years of dependable service without replacement of thermostatic element. Bulletin No. 115.

Hospital Sterilizer Control Valve—Makes sterilizer noiseless and saves steam. Bulletin No. 122.

Thermostatic Steam and Water Mixer—Automatically heats cold water with high pressure steam and delivers warm water at any temperature up to 120 deg. fahr. Bulletins No. 137 and No. 137-A.

Style D Steam and Water Mixer—Small, non-thermostatic mixer; supplies warm water for wash sinks, shower baths, and processes requiring a low cost warm water supply. Safe against scalding, easy to install, noiseless. Heats only the amount of water desired at the time. Capacity 10 gals. per min. with 40 lbs. pressure on supply lines. Bulletin No. 137-A.

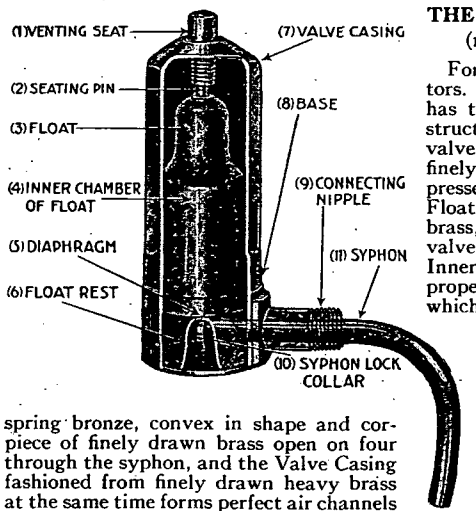
Pressure Reducing Valve for steam, air and water. Simple, durable, accurate. Bulletin No. 118.

Complete set of bulletins describing the entire Powers line will be sent upon request.

The Dole Valve Company

1913-1933 Carroll Avenue, CHICAGO, ILL.

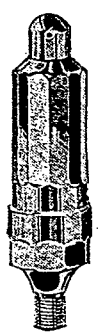
Manufacturers of High Grade Radiator Valves and Brass Specialties



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 vaive 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 two sizes—¼ and ⅛ in.

List Price.....$2.00

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

The New Modulating Valve—*with a vertical seat*

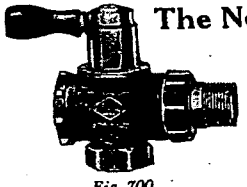


Fig. 700, Jenkins Modulating Valve

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:

(1) Foreign matter cannot lodge on seat and prevent tight closing of valve.

(2) Steam enters at top and condensation drains out at the bottom of the seat—an important feature when valve is used on a one-pipe system, because flow of steam is not retarded by the return of condensation. Gurgling, water-hammer and shock are avoided.

(3) 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. Handle of red Bakelite does not get hot, will not crack or chip.

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.

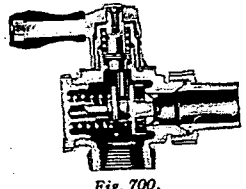


Fig. 700, Sectional View

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 Joisting; and Moncrieff Scotch Gauge Glasses.



Fig. 106, Bronze Globe, Screwed

RADIATOR VALVES

Regularly furnished with black composition wheels, or, if desired, with bronze, wire or iron wheels.

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. 552, Bronze Swing Check Valve

CATALOG

A catalog of all the Jenkins valves, giving sizes, styles and list prices, mailed on request.

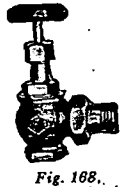


Fig. 168, Radiator Angle, with Union

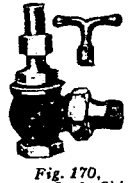


Fig. 170, Bronze Lock Shield Radiator Angle, with Union

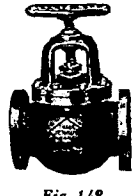


Fig. 142, Iron Body Globe, Flanged



Fig. 325, Iron Body Gate, Screwed

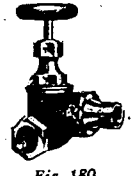


Fig. 180, Bronze Offset Corner, Radiator with Union



Fig. 351, Bronze Radiator Gate, Screwed



Fig. 370, Bronze Gate, Screwed

Pierce, Butler & Pierce Mfg. Corp.

41 East 42nd Street — NEW YORK CITY

Factories

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Radiator Valves, High Pressure Valves, Hot Water Valves, Hot Water Thermometers, Pressure and Altitude Gages

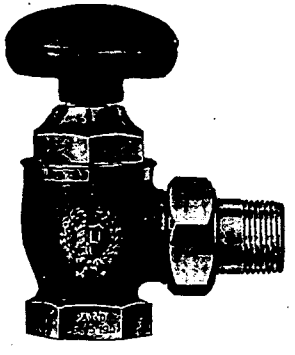


Fig. 136. Angle Valve with Union
(With Genuine Jenkins Bros. Disc)

A Newly Designed PIERCE PACKLESS VALVE for Vapor, Water or Steam

This new addition to the Pierce Packless line of Radiator Valves made by the Pierce, Butler & Pierce Manufacturing Corporation, is an especially compact and pleasing pattern. It is generously proportioned and embodies the best attainable in point of material and workmanship.

It is made in the angle type only, both plain and with modulating dial and button, in sizes ½ to 2 in., inclusive.

Genuine Jenkins Brothers discs are used. The handle is of the mushroom type made of Bakelite, beautifully polished, which is a perfect heat insulator, insuring against discomfort in manipulating the valve. Lever handle on modulating valve if desired.

The body is sturdy in its proportions, and consequently is not likely to be injured or distorted in the process of installation. The nickel plating is unusually heavy and substantial.

Marsh Valve Company

Plant and General Offices: DUNKIRK, NEW YORK

Exclusive Sales Distributors:

APPLETON & LIPTROTT, INC., 1480 Broadway, New York City

Edward T. Hetherington,
1718 Sansom Street, Philadelphia, Pa.

United States Radiator Corporation,
General Offices, Detroit, Mich.
All territory east of West lines of Michigan and Ohio and north of Virginia, except New York and Philadelphia

John W. Mabbs,
431 S. Dearborn Street, Chicago, Ill.

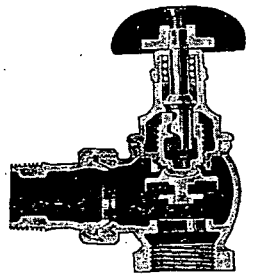
Jas. P. Marsh & Company,
118 S. Clinton Street, Chicago, Ill.
All territory south of Ohio River and west of Michigan and Ohio, except Cook County, Chicago, Ill.

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

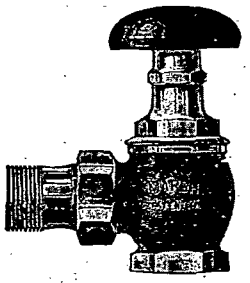


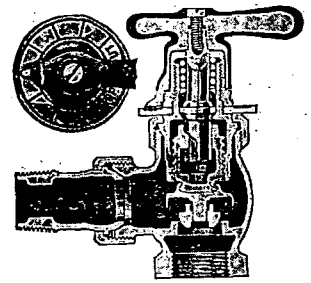
Fig. 138

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 three-quarter inch valve, and from this up to one and one-quarter turns for balance of line through two inches. 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. 139

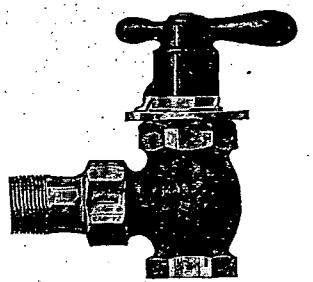
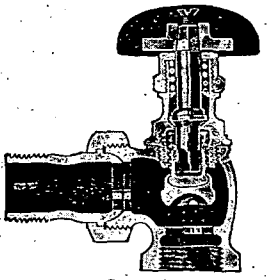


Fig. 151

The Modulation or Graduation is accomplished by a double cone disc nut, regulating volume of steam, according to pressure, until indicator registers valve about two-thirds open, when lower cone on disc nut is brought into use and 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

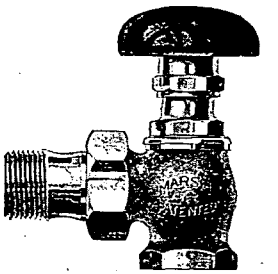
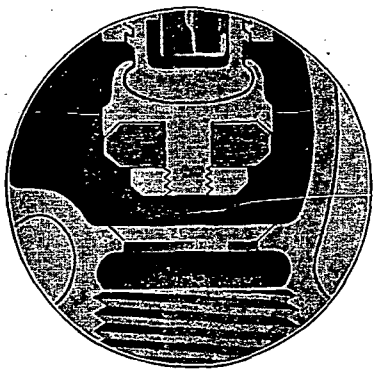


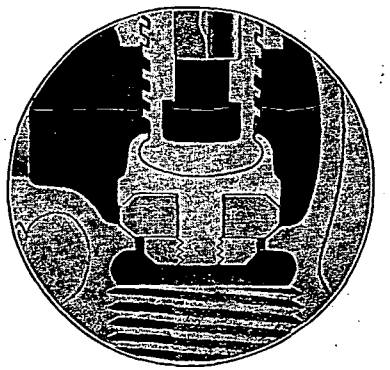
Fig. 141

Marsh Cone Discs are without question the greatest improvement in radiator valve construction in the past fifty years or since the composition disc replacing 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.

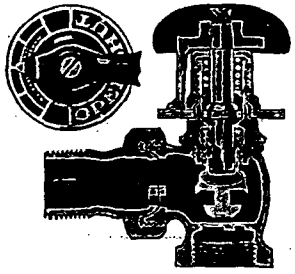
Third: While the life of these cone discs because of construction, as proven by tests, is three to five times the life of a flat disc, and a CRACKED DISC IS IMPOSSIBLE, the matter of exchange if desired is very simple, as to remove disc nut the disc will drop from disc-holder, while with a flat disc 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 perfect 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. Positively a better valve at a less cost than can be had from any other source.

MARSH RE-ENFORCED MODULATED CONE DISC RADIATOR VALVES



Cone-Disc Mod.

Oval Wheel, Lever Handle or Lock Shield

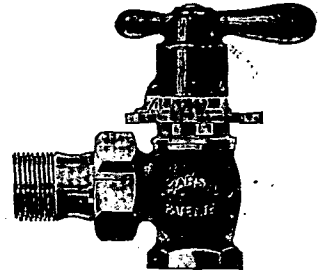


Fig. 147

The Modulation feature of our Cone Disc Line is the same as with our union bonnet flat disc Figure 131.

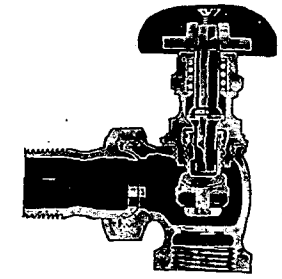
Our Cone Disc Modulated valves unless otherwise ordered are fitted with Oval Wheel, the same as our Graduated Water valve, Figure 139.

With our Oval Wheel Handle you have 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

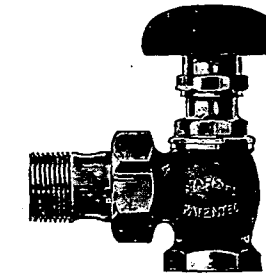


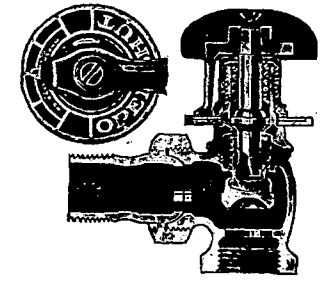
Fig. 137

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 positively will not stick or leak.

They will hold high pressure suitable for forced circulation up to any pressure radiation will stand, and cost no more than the cheap competition valves.

MARSH RE-ENFORCED GRADUATED WATER RADIATOR VALVES



Water Graduated

Oval Wheel, Lever Handle or Lock Shield

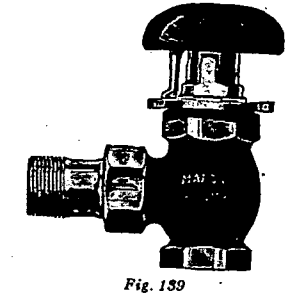


Fig. 139

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.

The John Call Company

VENTILATING SPECIALISTS

128 North Franklin Street PHILADELPHIA, PA.

BRANCHES IN ALL PRINCIPAL CITIES

ROOF VENTILATORS AND WINDOW VENTILATORS



Products

The Liberty Ventilator. A roof ventilator for any type building or enclosure, such as Schools, Hospitals, Foundries, Barns, Churches, Armories, Residences and similar structures.

Also highly efficient for increasing draft in chimneys, flues, stacks, etc. Back drafts impossible, regardless of wind conditions. Rain or snow cannot penetrate. No moving parts to rattle or require attention. Substantially and staunchly built of any metal desired. Large stocks for prompt shipment.

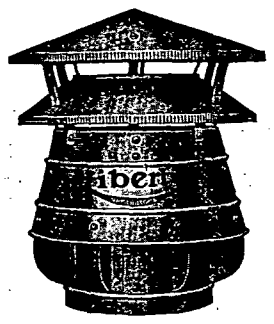
The Pul-Air Impingement Ventilator



The Pul-Air Ventilator

A good practical roof ventilator of the mushroom type, consisting of a double-cone top. Scientific storm band and impingement band. Made in every size and of any metal. Strongly built. Large stocks carried. Will not back draft; maximum of free areas.

THE LIBERTY VENTILATOR



LIBERTY VENTILATOR

Good architectural lines and symmetry



ANATOMY OF LIBERTY VENTILATOR—showing positive venturi action. White arrows indicate outside winds. Black arrows foul air being pulled out

Embraces all four principles of scientific ventilation:—1st, Impingement; 2nd, Positive and Negative sides of Ventilators; 3rd, Siphonage; 4th, Stack Action. A positive and complete venturi action.

The Liberty Ventilator combines the principles of siphonage and air impingement. This in conjunction with the positive and negative sides of the ventilator creates a vacuum to which the air is naturally sucked regardless of the direction of the wind. Stack action, also, is so accommodated as to accelerate this movement. The free areas of the Liberty ventilator create no resistant constant. **Send for copy of tests conducted by Carnegie Institute of Technology, and Massachusetts Institute of Technology.**

Mechanical and Engineering Data, Service Talks, Catalogues and Prices gladly sent on request.

Royal Ventilator Company

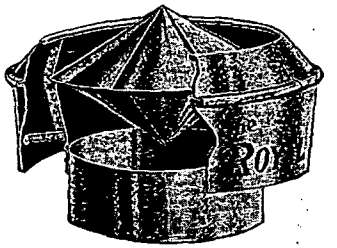
415 Locust Street ∴ PHILADELPHIA, PA.

Manufacturers of Ventilators and Exhaust Heads

PRODUCTS:

Royal Double Cone Ventilators of Galvanized Steel, Copper, Toncan Metal, Armco Iron, Etc., Glass Top Ventilators; Rectangular and Square Ventilators; Fire-retarding Ventilators; Smoke-jack and Combination Ventilators; Insect and Bird-proof Ventilators; Steam Exhaust Heads.

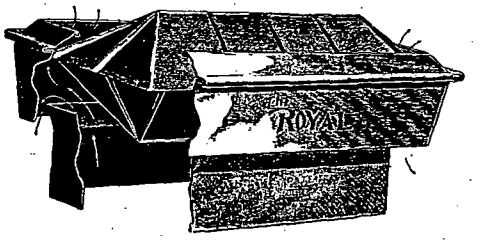
The Royal Double Cone Ventilator is designed to produce maximum ventilating efficiency. The **Royal** will give effective ventilation during adverse weather conditions; at all times an upward draft is maintained. Schools, hospitals, theatres, also factories, power-houses and foundries are among the types of buildings effectively ventilated with the **Royal.** The **Royal** is 100 per cent efficient.



Patented Trade Mark Reg. U. S. Pat. Office

The principles that have made **Royals** superior:

1. **Double Tapered Outer Frustums.**—The wind pressure deflected over and under the edges of the frustums constitutes a strong up draft.
2. **The Inverted Cone.**—Placed directly in the center of ascending air, which on striking it is deflected directly upward and outward.
3. **Radiating Ribs in the Cones.**—These prevent the air from swirling around, and also add to the firm construction.



"ROYAL" Rectangular Ventilators, made to any desired size, Glass or Metal Top, for Schools, Mills, etc.

4. **Strenght and Rigidity.**—Edgewise galvanized malleable iron braces, lapped seams, wired edges.
5. **Graceful Design.**—Efficient, Faultless, Storm-proof.

Send for Catalogue.

Dimensions and Technical Information

Vent Size Inches	Cu. Ft. Exhaust per Minute, Wind, 5 Miles per Hour — Temperature Difference in Building and Outside		Height Inches	Outside Diameter Inches	Area	Gauge Iron	Ounces of Copper
	0°	20°					
10	141	186	12	16	78	24	16
12	159	417	13	19	113	24	16
14	306	426	15	22	164	24	16
16	388	512	17	26	201	24	16
18	490	832	18	29	255	24	16
20	606	911	21	31	314	24	16
24	874	1373	24	39	453	22	18
28	1186	2080	26	45	615	20	18
30	1364	2390	26	45	707	20	18
34	1765	2987	28	50	908	20	18
36	1961	3361	28	56	1017	20	18
40	2424	4124	34	61	1257	20	20
42	2673	4680	34	68	1386	18 and 20	20
48	3489	5987	39	75	1809	18 and 20	20
54	5414	8304	42	84	2390	18 and 20	20
60	6665	9721	47	94	2807	18	24
66	7851	13346	52	103	3504	18	24
72	10682	16910	54	108	4071	18	24

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AIR COCKS (*See Cocks, Air*)

AIR CONDITIONING
American Blower Co.
Atmospheric Conditioning Corp.
Badger, E. B., & Sons Co.
Bishop & Babcock Sales Co., The
Buffalo Forge Co.
Call, John, Co., The
Carrier Air Conditioning Corp. of America
Carrier Engineering Corp.
Clarage Fan Co.
Cooling and Air Conditioning Corp.
Cooling Tower Co.
Drying Systems, Inc.
Grinnell Company, Inc.
Ilg Electric Ventilating Co.
Langenberg Mfg. Co.
Midwest Air Filters, Inc.
Modine Mfg. Co.
Herman Nelson Corp.
New York Blower Co.
Pecco, Inc.
Reed Air Filter Co., Inc.
Skinner Bros. Mfg. Co., Inc.
Spray Engineering Co.
Sturtevant, B. F., Co.
Wing, L. J., Mfg. Co.
York Heating & Ventilating Corp.

AIR COOLERS
American Blower Co.
Aerofin Corp.
Cooling Tower Co.
Modine Mfg. Co.

AIR DIFFUSERS (*See Diffusers, Air*)

AIR DRYING (*See Drying Apparatus*)

AIR ELIMINATORS (*See Eliminators, Air*)

AIR FILTERS (*See Filters, Air*)

AIR PUMPS (*See Pumps, Air*)

AIR TESTING INSTRUMENTS
American Blower Co.
Hays Corp., The
Hill, E. Vernon, Co.

AIR VALVES (*See Valves, Air*)

AIR WASHERS
American Blower Co.
Atmospheric Conditioning Corp.
Badger, E. B., & Sons Co.
Bishop & Babcock Sales Co., The
Buffalo Forge Co.
Call, John, Co., The
Carrier Engineering Corp.
Clarage Fan Co.
Cooling and Air Conditioning Corp.
Cooling Tower Co.
Ilg Electric Ventilating Co.
Midwest Air Filters, Inc.
New York Blower Co.
Reed Air Filter Co., Inc.
Spray Engineering Co.
Sturtevant, B. F., Co.

AMMONIA COILS (*See Coils, Ammonia*)

ASBESTOS AND INSULATING PRODUCTS
Celotex Co.
Hays Corp., The
Johns-Manville, Inc.
National Radiator Co.
Ric-wil Co.
Universal Gypsum & Lime Co.

ASBESTOS—Sheet
Johns-Manville, Inc.

AUTOMATIC FURNACES (*See Furnaces, Automatic*)

BAKING EQUIPMENT
Drying Systems, Inc.
Westinghouse Electric & Mfg. Co.

BLAST GATES (*See Gates, Blast*)

BLOWERS—Centrifugal
American Blower Co.
Buffalo Forge Co.
Clarage Fan Co.
Ilg Electric Ventilating Co.
Nesbitt, John J., Inc.
New York Blower Co.
O-E Specialty Mfg. Co.
Pecco, Inc.
Skinner Brothers Mfg. Co.
Sturtevant, B. F., Co.
Westinghouse Electric & Mfg. Co.
York Heating & Ventilating Corp.

Fan
American Blower Co.
Bishop & Babcock Sales Co., The
Clarage Fan Co.
Honeywell Heating Specialties Co.
Ilg Electric Ventilating Co.
Langenberg Mfg. Co.
Modine Mfg. Co.
Nash Engineering Co.
Nesbitt, John J., Inc.
New York Blower Co.
Pecco, Inc.
Sturtevant, B. F., Co.
Westinghouse Electric & Mfg. Co.
Wing, L. J., Mfg. Co.
York Heating & Ventilating Corp.

Forced Draft
American Blower Co.
Buffalo Forge Co.
Clarage Fan Co.
Sturtevant, B. F., Co.
Wing, L. J., Mfg. Co.

Pressure
American Blower Co.
Buffalo Forge Co.
Clarage Fan Co.
Ilg Electric Ventilating Co.
Nash Engineering Co.
New York Blower Co.
Sturtevant, B. F., Co.
Wing, L. J., Mfg. Co.

Turbine
American Blower Co.
Wing, L. J., Mfg. Co.

Ventilating
American Blower Co.
Bishop & Babcock Sales Co., The
Buffalo Forge Co.
Clarage Fan Co.
Ilg Electric Ventilating Co.
Langenberg Mfg. Co.
Modine Mfg. Co.
Herman Nelson Corp.
New York Blower Co.
Pecco, Inc.
Sturtevant, B. F., Co.
Westinghouse Electric & Mfg. Co.
Wing, L. J., Mfg. Co.
York Heating & Ventilating Corp.

BOILER—Compounds (*See Compounds, Boiler*)

Controllers (*See Controllers*)

Coverings (*See Asbestos and Insulating Products*)

Feeders
Kieley & Mueller, Inc.
McAlear Mfg. Co.
McDonnell & Miller

Feed Pumps (*See Pumps*)

Headers (*See Headers*)

Liquid
No Rad Rust Corp.
O-E Specialty Mfg. Co.
Vinco Co.
"X" Laboratories

Protecting Devices
Hoffman Specialty Co.
McDonnell & Miller
Marsh, Jas. P., & Co.
Neptune Meter Co.
Trane Co., The
U. S. Radiator Corp.

Scale Remover (*See Scale Remover, Boiler*)

BOILERS—Furnace Heat
CoKal Co.

Heating (*Automatic Heat*)
Newport Boiler Co.

Heating (*Coal Fired*)
American Radiator Co.
Ames Iron Works
Ironton Bernhard Boiler Co.
Bigelow Co., The
Burnham Boiler Corp.
Continental Heater Corp.
Fitzgibbons Boiler Co., Inc.
General Boilers Co.
Harrisburg Star Boiler Corp.
Hart & Crouse Co.
Heggie-Simplex Boiler Co.
International Heater Co.
Kewanee Boiler Co.
Lebanon Boiler Works
National Radiator Co.
Newport Boiler Co.
Niagara Radiator & Boiler Co.
Oil City Boiler Works
Petty, J. K., & Co., Inc.
Page, Wm. H., Boiler Co.
Pierce, Butler & Pierce Mfg. Corp.
Prox, Frank, Co.
Reading Heater & Supply Co.
Richardson & Boynton Co.
Richmond Radiator Co.
Smith, H. B., Co.
Spencer Heater Co.
Thatcher Co., The
Titusville Iron Works
U. S. Radiator Corp.
Universal Smokeless Boiler Co.
Utica Heater Co.
Weil-McLain Co.

Heating (*Gas Fired*)
American Radiator Co.
Ames Iron Works
Ironton Bernhard Boiler Co.
Bigelow Co., The
Burnham Boiler Corp.
Continental Heater Corp.
Fitzgibbons Boiler Co., Inc.
General Boilers Co.
Hart & Crouse Co.
Heggie-Simplex Boiler Co.
Kewanee Boiler Co.
National Radiator Co.
Neptune Meter Co.
Newport Boiler Co.
Niagara Radiator & Boiler Co.
Oil City Boiler Works
Page, Wm. H., Boiler Co.
Pierce, Butler & Pierce Mfg. Corp.
Prox, Frank, Co.
Richmond Radiator Co.
Spencer Heater Co.
Titusville Iron Works
U. S. Radiator Corp.
Universal Smokeless Boiler Co.

Heating (*Oil Fired*)
American Radiator Co.
Ames Iron Works
Ironton Bernhard Boiler Co.
Bigelow Co., The
Burnham Boiler Corp.
Continental Heater Corp.
Fitzgibbons Boiler Co., Inc.
General Boilers Co.
Harrisburg Star Boiler Corp.
Hart & Crouse Co.
Heggie-Simplex Boiler Co.
International Heater Co.
Kewanee Boiler Co.
Lebanon Boiler Works
Newport Boiler Co.
Niagara Radiator & Boiler Co.
Oil City Boiler Works
Page, Wm. H., Boiler Co.
Petty, J. K., & Co., Inc.
Pierce, Butler & Pierce Mfg. Corp.
Prox, Frank, Co.
Richmond Radiator Co.
Smith, H. B., Co.
Spencer Heater Co.
Sturtevant, B. F., Co.
Titusville Iron Works
U. S. Radiator Corp.
Universal Smokeless Boiler Co.
Utica Heater Co.
Weil-McLain Co.

Tubular
Ames Iron Works
Bigelow Co., The
Burnham Boiler Corp.
Fitzgibbons Boiler Co., Inc.
Harrisburg Star Boiler Corp.
Heggie-Simplex Boiler Co.
Kewanee Boiler Co.
Lebanon Boiler Works
Oil City Boiler Works
Petty, J. K., & Co., Inc.
Pierce, Butler & Pierce Mfg. Corp.
Spencer Heater Co.
Titusville Iron Works

BRACKETS (*See Hangers, Pipe and Radiator, and Radiator Brackets*)

BREECHINGS
Pierce, Butler & Pierce Mfg. Corp.

BURNERS—Oil (*For Heating Boilers and Furnaces*)
American NoKol Co.
Automatic Burner Corp.
Ballard Oil Equipment Co.
Johnson, S. T., Co.
Winslow Boiler & Engineering Co.

CABINETS—Furnace
Art Metal Radiator Cover Co.

Heat
Bridgeport Rolling Mills, Inc.
Herman Nelson Corp.
Trane Co.

CALORIMETERS—Steam
Ellison, Lewis M.

CEMENT—Asbestos (*See Asbestos and Insulating Products*)

Fire Brick
Johns-Manville, Inc.

Pipe Joint
Grinnell Company, Inc.
Johns-Manville, Inc.

Water Proof
Johns-Manville, Inc.

CENTRIFUGAL DRYERS (*See Drying Apparatus*)

CLEANSER, BOILER AND HEATING SYSTEM
No Rad Rust Corp.
Vinco Co.
"X" Laboratories

COAL SAVER
American Blower Co.
Combustion Specialties Corp.
Hays Corp., The
Minneapolis Heat Regulator Co.
O-E Specialty Mfg. Co.

COCKS—Air
Bishop & Babcock Sales Co., The
Mueller Co.

Boiler Drain
Mueller Co.

Boiler Supply
Mueller Co.

Gage
Bishop & Babcock Sales Co., The
Jenkins Bros.
Marsh, Jas. P., & Co.
O-E Specialty Mfg. Co.

COILS—Ammonia
Badger, E. B., & Sons Co.
Grinnell Company, Inc.
Whitlock Coil Pipe Co.

Blast
Aerofin Corp.
American Blower Co.
American Radiator Co.
Modine Mfg. Co.
New York Blower Co.
Rome-Turney Radiator Co.
Stickle Steam Specialties Co.
York Heating & Ventilating Corp.

Pipe
American Blower Co.
Badger, E. B., & Sons
Grinnell Co., Inc.
Whitlock Coil Pipe Co.
York Heating & Ventilating Corp.

Tank
Badger, E. B., & Sons
Kewanee Boiler Co.
Whitlock Coil Pipe Co.
York Heating & Ventilating Corp.

COLLECTORS, DUST (*See Dust Collectors*)

COLUMNS—Water
American Radiator Co.
Oil City Boiler Works
Page, Wm. H., Boiler Co.
Titusville Iron Works

COMPOUNDS—Boiler
No Rad Rust Corp.
O-E Specialty Mfg. Co.
Richardson & Boynton Co.
Vinco Co.
"X" Laboratories

COMPRESSORS
Bishop & Babcock Sales Co., The
Nash Engineering Co.
O-E Specialty Mfg. Co.
Powers Regulator Co.
Sturtevant, B. F., Co.
Trane Co.
Worthington Pump & Machinery Corp.

CONDENSERS
Alberger Heater Co.
Buffalo Steam Pump Co.
Carrier Engineering Corp.
Frank, O. E., Heater & Engineering Co., Inc.
Westinghouse Electric & Mfg. Co.
Whitlock Coil Pipe Co.
Worthington Pump & Machinery Corp.

CONDUIT—Underground
Johns-Manville, Inc.
O-E Specialty Mfg. Co.
Ric-wil Co.

Control Equipment
Absolute Con-tac-tor Corp.
American Radiator Co.
Honeywell Heating Specialties Co.
Johnson Service Co.
Minneapolis Heat Regulator Co.
Powers Regulator Co.

CONTROL SWITCHES (*See Switches, Control*)

CONTROLLERS—Boiler
Absolute Con-tac-tor Corp.
American Radiator Co.
American Schaeffer & Budenberg Corp.
Davis, G. M., Regulator Co.
Hays Corp., The
Honeywell Heating Specialties Co.
Kieley & Mueller, Inc.
Klipfel Mfg. Co.
McDonnell & Miller
Powers Regulator Co.
Sarco Co., Inc.
Stickle Steam Specialties Co.
Taylor Instrument Companies

Electric Heat
Absolute Con-tac-tor Corp.
American Radiator Co.
Hays Corp., The
Johnson Service Co.
Minneapolis Heat Regulator Co.
Powers Regulator Co.
Taylor Instrument Companies
Westinghouse Electric & Mfg. Co.

Fan Engine
American Blower Co.
Clarage Fan Co.
Kieley & Muller, Inc.
Klipfel Mfg. Co.
Mason Regulator Co.
McAlear Mfg. Co.
Mueller Co.

Feed Water
American Radiator Co.
American Schaeffer & Budenberg Corp.
Davis, G. M., Regulator Co.
Hays Corp., The
Kieley & Mueller, Inc.
McAlear Mfg. Co.
McDonnell & Miller
O-E Specialty Mfg. Co.
Sarco Co., Inc.
Stickle Steam Specialties Co.
Taylor Instrument Companies

Motor
Absolute Con-tac-tor Corp.
American Radiator Co.
Economy Pumping Machinery Co.
Hays Corp., The
Mason Regulator Co.
Taylor Instrument Companies
Trane Co.
Westinghouse Electric & Mfg. Co.

Pump
Absolute Con-tac-tor Corp.
American Radiator Co.
Buffalo Steam Pump Co.
Chicago Pump Co.
Davis, G. M., Regulator Co.
Economy Pumping Machinery Co.
Kieley & Mueller, Inc.
Klipfel Mfg. Co.
Mason Regulator Co.
McAlear Mfg. Co.
O-E Specialty Mfg. Co.
Stickle Steam Specialties Co.
Westinghouse Electric & Mfg. Co.
Yeomans Brothers Co.

Shower Bath
Mueller Co.
Powers Regulator Co.

Tank
Absolute Con-tac-tor Corp.
American Radiator Co.
American Schaeffer & Budenberg Corp.
Davis, G. M., Regulator Co.
Hays Corp., The
Kieley & Mueller, Inc.
Klipfel Mfg. Co.
Mason Regulator Co.
McAlear Mfg. Co.
Powers Regulator Co.
Sarco Co., Inc.
Stickle Steam Specialties Co.
Taylor Instrument Companies

Temperature (*See Regulators, Temperature*)

CONVEYING SYSTEMS (*See Systems, Dust Collecting and Exhaust*)

COOLING EQUIPMENT—Building
American Blower Co.
Atmospheric Conditioning Corp.
Call, John, Co., The
Carrier Air Conditioning Corp. of America
Carrier Engineering Corp.
Cooling & Air Conditioning Corp.
Cooling Tower Co.
Drying Systems, Inc.
Sturtevant, B. F., Co.

COOLING TOWERS
Buffalo Forge Co.
Carrier Engineering Corp.
Cooling Tower Co.
Spray Engineering Co.

Cooling Ponds
Spray Engineering Co.

COUPLINGS
Mogul Machine Co.

COVERING—Boiler (*See Asbestos and Insulating Products*)

Magnesia
Johns-Manville, Inc.

Pipe and Tank
Johns-Manville, Inc.
Ric-wil Co.

DAMPER—Quadrants
York Heating & Ventilating Corp.

DAMPER REGULATORS
(*See Regulators, Damper*)

DEHUMIDIFYING APPARATUS
American Blower Co.
Atmospheric Conditioning Corp.
Buffalo Forge Co.
Call, John, Co., The
Carrier Engineering Corp.
Clarage Fan Co.
Cooling and Air Conditioning Corp.
Cooling Tower Co.
Drying Systems, Inc.
Modine Mfg. Co.
New York Blower Co.
Pecco, Inc.
Reed Air Filter Co.
Skinner Bros. Mfg. Co., Inc.
Spray Engineering Co.
Stickle Steam Specialties Co.
Sturtevant, B. F., Co.

DIFFUSERS—Air
Carrier Engineering Corp.
Knowles Mushroom Ventilator Co.
Spray Engineering Co.
Sturtevant, B. F., Co.

DRAFT GAGES (*See Gages, Draft*)

DRYING APPARATUS
American Blower Co.
Atmospheric Conditioning Corp.
Bishop & Babcock Sales Co., The
Buffalo Forge Co.
Call, John, Co., The
Carrier Engineering Corp.
Clarage Fan Co.
Cooling and Air Conditioning Corp.
Drying Systems, Inc.
Economy Pumping Machinery Co.
Ilg Electric Ventilating Co.
Langenberg Mfg. Co.
Lebanon Boiler Works
Modine Mfg. Co.
New York Blower Co.
Pecco, Inc.
Petty, J. K., & Co., Inc.
Skinner Bros. Mfg. Co.
Stickle Steam Specialties Co.
Sturtevant, B. F., Co.
Wing, L. J., Mfg. Co.
York Heating & Ventilating Corp.

DUST COLLECTING SYSTEMS (*See Systems, Dust Collecting*)

DUST COLLECTORS
American Blower Co.
Buffalo Forge Co.
Call, John, Co., The
Carrier Engineering Corp.
Cooling Tower Co.
Midwest Air Filters, Inc.
New York Blower Co.
Pecco, Inc.
Skinner Bros. Mfg. Co., Inc.
Spray Engineering Co.
Sturtevant, B. F., Co.
York Heating & Ventilating Corp.

DUST COUNTERS
Hill, E. Vernon, Co.

DUST FILTERS
Cooling Tower Co.
Drying Systems, Inc.
Duro Air Filter Co.
Midwest Air Filters, Inc.
Reed Air Filters Co., Inc.
Spray Engineering Co.

DUST SEPARATORS (*See Separators, Dust*)

ELBOWS—Radiator
American Radiator Co.
Burnham Boiler Corp.
Fulton Co.
U. S. Radiator Corp.

ELECTRIC MOTORS (*See Motors, Electric*)

ELIMINATORS—Air
Badger, E. B., & Sons Co.
Bishop & Babcock Sales Co., The
Call, John, Co., The
Dunham, C. A., Co.
Hoffman Specialty Co., Inc.
Marsh, Jas. P., & Co.
McAlear Mfg. Co.
Monash-Younker Co., Inc.
Mouat Vapor Heating Co.
New York Blower Co.
O-E Specialty Mfg. Co.
Pecco, Inc.
Royal Ventilator Co.
Sarco Co., Inc.
Skinner Bros., Mfg. Co.
Sturtevant, B. F., Co.
Trane Co.

ENGINES—Fan
American Blower Co.
Buffalo Forge Co.
Clarage Fan Co.
New York Blower Co.
Sturtevant, B. F., Co.

Steam (*Automatic, High Speed, Throttling, Una-Flow, and Vertical*)
American Blower Co.
Ames Iron Works
Clarage Fan Co.
Pierce, Butler & Pierce Mfg. Corp.
Sturtevant, B. F., Co.
Titusville Iron Works

EXHAUST FANS (*See Fans, Exhaust*)

EXHAUST HEADS
Buffalo Forge Co.
Call, John, Co., The
Illinois Engineering Co.
Kieley & Mueller, Inc.
McAlear Mfg. Co.
Patterson-Kelley Co.
Pecco, Inc.
Royal Ventilator Co.
Skinner Bros. Mfg. Co., Inc.
Sturtevant, B. F., Co.

EXHAUST SYSTEMS
American Blower Co.
Buffalo Forge Co.
Call, John, Co., The
Carrier Engineering Corp.
Clarage Fan Co.
Cooling and Air Conditioning Corp.
Ilg Electric Ventilating Co.
New York Blower Co.
Pecco, Inc.
Skinner Bros. Mfg. Co., Inc.
Sturtevant, B. F., Co.
Wing, L. J., Mfg. Co.
York Heating & Ventilating Corp.

EXPANSION JOINTS (*See Joints, Expansion*)

FANS—Blower (*See Blowers, Fan*)

Booster
American Blower Co.
Honeywell Heating Specialties Co.

Exhaust
American Blower Co.
Bishop & Babcock Sales Co., The
Buffalo Forge Co.
Clarage Fan Co.
Ilg Electric Ventilating Co.
Langenberg Mfg. Co.
Herman Nelson Corp.
New York Blower Co.
Pecco, Inc.
Skinner Bros. Mfg. Co., Inc
Sturtevant, B. F., Co.
Westinghouse Electric & Mfg. Co.
Wing, L. J., Mfg. Co.
York Heating & Ventilating Corp.

Ventilating
American Blower Co.
Bishop & Babcock Sales Co., The
Buffalo Forge Co.
Call, John, Co., The
Clarage Fan Co.
Ilg Electric Ventilating Co.
Langenberg Mfg. Co.
New York Blower Co.
O-E Specialty Mfg. Co.
Pecco, Inc.
Skinner Bros. Mfg. Co., Inc.
Stickle Steam Specialties Co.
Sturtevant, B. F., Co.
Westinghouse Electric & Mfg. Co.
Wing, L. J., Mfg. Co.
York Heating & Ventilating Corp.

FEEDERS (*See Boiler Feeders*)

Boiler
Kieley & Mueller, Inc.
McDonnell & Miller

Water
Kieley & Mueller, Inc.
McDonnell & Miller

FILTERS—Air
American Blower Co.
Call, John, Co., The
Cooling Tower Co.
Drying Systems, Inc.
Duro Air Filter Co.
Midwest Air Filters, Inc.
Herman Nelson Corp.
Reed Air Filter Co., Inc.
Spray Engineering Co.
Sturtevant, B. F., Co.

FIRE BRICK CEMENT (*See Cement, Fire Brick*)

FITTINGS—Flanged
Grinnell Company, Inc.

Furnace
International Heater Co.
Langenberg Mfg. Co.

Pipe
Grinnell Company, Inc.
International Heater Co.
Westinghouse Electric & Mfg. Co.

FOG ELIMINATORS
American Blower Co.
Carrier Engineering Corp.
Ilg Electric Ventilating Co.
Modine Mfg. Co.
Wing, L. J., Mfg. Co.
York Heating & Ventilating Corp.

FOUNDATIONS
Korfund Co., The
Cork Foundation Co.

FURNACES—Automatic
New York Blower Co.
Sanford Riley Stoker Co.

Boiler
CoKal Co.

Electric
Westinghouse Electric & Mfg. Co.

Pipeless
Hart & Crouse Co.
International Heater Co.
Langenberg Mfg. Co.
New York Blower Co.
Thatcher Co., The
Utica Heater Co.

Smokeless
CoKal Co.

Warm Air
Hart & Crouse Co.
International Heater Co.
Langenberg Mfg. Co.
New York Blower Co.
Sturtevant, B. F., Co.
Thatcher Co., The
Utica Heater Co.

GAGE—Boards
American Schaeffer & Budenberg Corp.
Bishop & Babcock Sales Co., The
Dunham, C. A., Co.
Hays Corp., The
Marsh, Jas. P., & Co.
Warren Webster & Co.

Cocks (*See Cocks, Gage*)

Glasses (*See Glasses, Gage*)

Valves (*See Valves, Gage*)

GAGES—Air Pressure
Hays Corp., The

Draft
American Schaeffer & Budenberg Corp.
Combustion Specialties Corp.
Ellison, Lewis M.
Hays Corp., The
Higgin Mfg. Co.
Hill, E. Vernon, Co.
Hoffman Specialty Co., Inc.
Taylor Instrument Companies
Warren Webster & Co.

Compound
American Schaeffer & Budenberg Corp.
Hoffman Specialty Co., Inc.
Trane Co.

Pressure
American Schaeffer & Budenberg Corp.
Bishop & Babcock Sales Co., The
Dunham, C. A., Co.
Hays Corp., The
Marsh, Jas. P., & Co.
Mouat Vapor Heating Co.
O-E Specialty Mfg. Co.
Pierce, Butler & Pierce Mfg. Corp.
Taylor Instrument Companies
Trane Co.
U. S. Radiator Corp.
Warren Webster & Co.

Steam
American Radiator Co.
American Schaeffer & Budenberg Corp.
Dunham, C. A., Co.
Hoffman Specialty Co.
Marsh, Jas. P., & Co.
O-E Specialty Mfg. Co.
Pierce, Butler & Pierce Mfg. Corp.
Taylor Instrument Companies
Trane Co.
U. S. Radiator Corp.
Warren Webster & Co.

Vacuum
American Radiator Co.
American Schaeffer & Budenberg Corp.
Bishop & Babcock Sales Co., The
Dunham, C. A., Co.
Hoffman Specialty Co.
Illinois Engineering Co.
Marsh, Jas. P., & Co.
O-E Specialty Mfg. Co.
Pierce, Butler & Pierce Mfg. Co.
Taylor Instrument Companies
Trane Co.
U. S. Radiator Corp.
Warren Webster & Co.

Water
American Radiator Co.
American Schaeffer & Budenberg Corp.
Marsh, Jas. P., & Co.
National Radiator Co.
Pierce, Butler & Pierce Mfg. Co.
Taylor Instrument Companies
U. S. Radiator Corp.

Furnaces (*See Furnaces, Gas*)

Heaters—Room (*See Heaters, Gas*)

Heating Systems (*See Heating Systems, Gas*)

Water Heaters
American Radiator Co.
Alberger Heater Co.
Page, Wm. H., Boiler Co.
Smith, H. B., Co.
Stickle Steam Specialties Co.
Thatcher Co., The
Universal Smokeless Boiler Co.

GASKETS—Asbestos
Jenkins Bros.
Johns-Manville, Inc.

Boiler
Johns-Manville, Inc.

Metallic
Johns-Manville, Inc.

Rubber
Jenkins Bros.
Johns-Manville, Inc.

GATES—Blast
American Blower Co.
Buffalo Forge Co.
Clarage Fan Co.
New York Blower Co.
Sturtevant, B. F., Co.
York Heating & Ventilating Corp.

GENERATOR COOLING SYSTEMS
American Blower Co.
Buffalo Forge Co.
Carrier Engineering Corp.
Cooling Tower Co.
Drying Systems, Inc.
Reed Air Filter Co.
Spray Engineering Co.
Sturtevant, B. F., Co.

GENERATORS—Electric
Honeywell Heating Specialties Co.
Sturtevant, B. F., Co.
Westinghouse Electric & Mfg. Co.

Heat (*See Boilers, Furnaces and Heaters*)

Hot-Water
American Radiator Co.
Alberger Heater Co.
Burnham Boiler Corp.
D. & T. Mfg. Co.
Excelso Specialty Works, Inc.
Frank, O. E., Heater & Engineering Co., Inc.
Honeywell Heating Specialties Co.
Page, Wm. H., Boiler Co.
Reading Heater & Supply Co.
Whitlock Coil Pipe Co.

Vacuum
Illinois Engineering Co.
McAlear Mfg. Co.
O-E Specialty Mfg. Co.
Trane Co.

GLASSES—Gage
Jenkins Bros.
O-E Specialty Mfg. Co.

GOVERNORS—Condensation
Davis, G. M., Regulator Co.
Kieley & Mueller, Inc.
Klipfel Mfg. Co.
McAlear Mfg. Co.
Trane Co., The
Warren Webster & Co.

Pump (*See Regulators, Pump*)

Vacuum (*See Regulators, Vacuum*)

GRATES—Dumping
Fitzgibbons Boiler Co., Inc.
Kewanee Boiler Co.
Neemes Foundry, Inc.
Oil City Boiler Works
Universal Smokeless Boiler Co.

Rocking
Kewanee Boiler Co.
Neemes Foundry, Inc.
Oil City Boiler Works
Universal Smokeless Boiler Co.

Shaking
CoKal Co.
Kewanee Boiler Co.
Neemes Foundry, Inc.
Oil City Boiler Works
Titusville Iron Works
Universal Smokeless Boiler Co.

Stationary
CoKal Co.

GRILLES AND REGISTERS (*See Registers and Grilles*)

HANGERS—Adjustable Pipe
Fitzgibbons Boiler Co., Inc.
Grinnell Company, Inc.
Healy-Ruff Co.
Modern Mfg. Co.
Smith, H. B., Co.

Pipe
Grinnell Company, Inc.
Healy-Ruff Co.
Kewanee Boiler Co.
Midwest Air Filters, Inc.
National Radiator Co.
Pierce, Butler & Pierce Mfg. Co.
York Heating & Ventilating Corp.

Radiator
American Radiator Co.
Grinnell Company, Inc.
Healy-Ruff Co.
Kewanee Boiler Co.
Modine Mfg. Co.
National Radiator Co.
Niagara Radiator & Boiler Co.
Pierce, Butler & Pierce Mfg. Co.
Smith, H. B., Co.
U. S. Radiator Corp.
York Heating & Ventilating Corp.

HEADERS
Alberger Heater Co.
Grinnell Company, Inc.

HEAT EXCHANGERS
American Blower Co.
Buffalo Forge Co.
Carrier Engineering Corp.
Drying Systems, Inc.
Frank, O. E., Heater & Engineering Co., Inc.
Modine Mfg. Co.
Patterson-Kelley Co.
Whitlock Coil Pipe Co.

HEATERS—Air
American Blower Co.
Frank, O. E., Heater & Engineering Co., Inc.
Modine Mfg. Co.
Herman Nelson Corp.
Nesbitt, John J., Inc.
New York Blower Co.
Pecco, Inc.
Spencer Heater Co.
Sturtevant, B. F., Co.
Warren Webster & Co.
Westinghouse Electric & Mfg. Co.
Wing, L. J., Mfg. Co.

Automatic Hot Water
American Radiator Co.
Excelso Specialty Works, Inc.
Ilg Electric Ventilating Co.
Kewanee Boiler Co.
Mueller Co.
Neptune Meter Co.

Blast
Aerofin Corp.
American Blower Co.
American Radiator Co.
Buffalo Forge Co.
Clarage Fan Co.
Modine Mfg. Co.
New York Blower Co.
O-E Specialty Mfg. Co.
Sturtevant, B. F., Co.
Wing, L. J., Mfg. Co.
York Heating & Ventilating Corp.

Cabinet
Bridgeport Rolling Mills, Inc.
Herman Nelson Corp.
Trane Co.

Fan System
Aerofin Corp.
American Blower Co.
Buffalo Forge Co.
Clarage Fan Co.
Ilg Electric Ventilating Co.
Modine Mfg. Co.
New York Blower Co.
O-E Specialty Mfg. Co.
Pecco, Inc.
Sturtevant, B. F., Co.
Wing, L. J., Mfg. Co.
York Heating & Ventilating Corp.

Feed Water
Alberger Heater Co.
Frank, O. E., Heater & Engineering Co., Inc.
Patterson-Kelley Co.
Stickle Steam Specialties Co.
Warren Webster & Co.
Whitlock Coil Pipe Co.
Worthington Pump & Machinery Corp.

Gas
American Radiator Co.
Universal Smokeless Boiler Co.

Hot Water Service
Alberger Heater Co.
American Radiator Co.
Excelso Specialty Works, Inc.
Frank, O. E., Heater & Engineering Co., Inc.
Heggie-Simplex Boiler Co.
International Heater Co.
Kewanee Boiler Co.
Neptune Meter Co.
Niagara Radiator & Boiler Co.
Oil City Boiler Works
Page, Wm. H., Boiler Co.
Patterson-Kelley Co.
Prox, Frank, Co.
Reading Heater & Supply Co.
Richardson & Boynton Co.
Smith, H. B., Co.
Spencer Heater Co.
Thatcher Co., The
U. S. Radiator Corp.
Weil-McLain Co.
Whitlock Coil Pipe Co.

Indirect
Aerofin Corp.
American Blower Co.
Buffalo Forge Co.
Excelso Specialty Works, Inc.
Ilg Electric Ventilating Co.
Modine Mfg. Co.
Newport Boiler Co.
Patterson-Kelley Co.
Skinner Bros. Mfg. Co., Inc.
Smith, H. B., Co.
Whitlock Coil Pipe Co.
York Heating & Ventilating Corp.

Industrial
American Blower Co.
Buffalo Forge Co.
Drying Systems, Inc.
Ilg Electric Ventilating Co.
Langenberg Mfg. Co.
Lebanon Boiler Works
Modine Mfg. Co.
Patterson-Kelley Co.
Pecco, Inc.
Petty, J. K., & Co., Inc.
Skinner Bros. Mfg. Co., Inc.
Sturtevant, B. F., Co.
Westinghouse Electric & Mfg. Co.
Wing, L. J., Mfg. Co.
York Heating & Ventilating Corp.

Instantaneous Hot Water
Alberger Heater Co.
Frank, O. E., Heater & Engineering Co., Inc.
Patterson-Kelley Co.
Powers Regulator Co.
Whitlock Coil Pipe Co.

Room
American Blower Co.
American Radiator Co.
Buffalo Forge Co.
International Heater Co.
Langenberg Mfg. Co.
Modine Mfg. Co.
Thatcher Co., The

Tank
Alberger Heater Co.
American Radiator Co.
Burnham Boiler Corp.
Frank, O. E., Heater & Engineering Co., Inc.
International Heater Co.
Kewanee Boiler Co.
National Radiator Co.
Neotune Meter Co.
O-E Specialty Mfg. Co.
Page, Wm. H., Boiler Co.
Patterson-Kelley Co.
Prox, Frank, Co.
Reading Heater & Supply Co.
Smith, H. B., Co.
Spencer Heater Co.
Thatcher Co., The
Universal Smokeless Boiler Co.
Weil-McLain Co.
Whitlock Coil Pipe Co.

Unit
Aerofin Corp.
American Blower Co.
Buffalo Forge Co.
Clarage Fan Co.
Ilg Electric Ventilating Co.
Langenberg Mfg. Co.
Modine Mfg. Co.
Herman Nelson Corp.
Nesbitt, John J., Inc.
New York Blower Co.
Pecco, Inc.
Skinner Bros. Mfg. Co., Inc.
Sturtevant, B. F., Co.
Wing, L. J., Mfg. Co.
York Heating & Ventilating Corp.

Water (*Incinerator*)
Alberger Heater Co.
Heggie-Simplex Boiler Co.
Kewanee Boiler Co.
Lebanon Boiler Works
Oil City Boiler Works
Petty, J. K., & Co., Inc.

HEATING AND VENTILATING APPARATUS
Aerofin Corp.
American Blower Co.
American Radiator Co.
Barnes & Jones
Bishop & Babcock Sales Co., The
Buffalo Forge Co.
Burnham Boiler Corp.
Call, John, Co., The
Carrier Engineering Corp.
Carrier Air Conditioning Corp. of America
Clarage Fan Co.
Cooling and Air Conditioning Corp.
Cooling Tower Co.
Davis, G. M., Regulator Co.
Duro Air Filter Co.
Fitzgibbons Boiler Co., Inc.
Fowler & Wolfe Mfg. Co.
Hart & Crouse Co.
Heggie-Simplex Boiler Co.
Ilg Electric Ventilating Co.
International Heater Co.
Langenberg Mfg. Co.
Marsh, Jas. P., & Co.
Midwest Air Filters, Inc.
Minneapolis Heat Regulator Co.
Modine Mfg. Co.
Nash Engineering Co.
Neptune Meter Co.
Newport Boiler Co.
New York Blower Co.
Niagara Radiator & Boiler Co.
O-E Specialty Mfg. Co.
Page, W. H., Boiler Co.
Pecco, Inc.
Prox, Frank, Co.
Reading Heater & Supply Co.
Reed Air Filter Co.
Richmond Radiator Co.
Sarco Co., Inc.
Skinner Bros. Mfg. Co.
Smith, H. B., Co.
Spray Engineering Co.
Stickle Steam Specialties Co.
Sturtevant, B. F., Co.
Thatcher Co., The
U. S. Radiator Corp.
Utica Heater Co.
Warren Webster & Co.
Wing, L. J., Mfg. Co.
York Heating & Ventilating Corp.

HEATING SPECIALTIES
American Blower Co.
American Radiator Co.
American Schaeffer & Budenberg Corp.
Barnes & Jones
Bishop & Babcock Sales Co., The
Buffalo Forge Co.
Burnham Boiler Corp.
Combustion Specialties Corp.
Cork Foundation Co.
Davis, G. M., Regulator Co.
Dunham, C. A., Co.
Fulton Co.
Grinnell Company, Inc.
Hays Corp., The
Hoffman Specialty Co., Inc.
Honeywell Heating Specialties Co.
Illinois Engineering Co.
Kieley & Mueller, Inc.
McAlear Mfg. Co.
McDonnell & Miller
Marsh, Jas. P., & Co.
Mason Regulator Co.
Minneapolis Heat Regulator Co.
Monash-Younker Co., Inc.
Mouat Vapor Heating Co.
Nash Engineering Co.
National Radiator Co.
Newport Boiler Co.
Niagara Radiator & Boiler Co.
O-E Specialty Mfg. Co.
Page, Wm. H., Boiler Co.
Powers Regulator Co.
Reading Heater & Supply Co.
Sarco Co., Inc.
Stickle Steam Specialties Co.
Trane Co.
U. S. Radiator Corp.
Warren Webster & Co.
Young Pump Co.

HEATING SYSTEMS—Gas
American Blower Co.
Carrier Engineering Corp.
McAlear Mfg. Co.
Marsh, James P., & Co.
Mueller Co.
Herman Nelson Corp.
Neptune Meter Co.
Newport Boiler Co.
New York Blower Co.
O-E Specialty Mfg. Co.
Spencer Heater Co.
Sturtevant, B. F., Co.
Trane Co.
Warren Webster & Co.

Hot Blast
Aerofin Corp.
American Blower Co.
American Radiator Co.
Buffalo Forge Co.
Carrier Engineering Corp.
Clarage Fan Co.
Grinnell Company, Inc.
Ilg Electric Ventilating Co.
Langenberg Mfg. Co.
Modine Mfg. Co.
New York Blower Co.
O-E Specialty Mfg. Co.
Pecco, Inc.
Skinner Bros. Mfg. Co., Inc.
Stickle Steam Specialties Co.
Sturtevant, B. F., Co.
Thatcher Co., The
Wing, L. J., Mfg. Co.
York Heating & Ventilating Corp.

Hot Water
Barnes & Jones
Buffalo Forge Co.
Burnham Boiler Corp.
D. & T. Mfg. Co.
Fitzgibbons Boiler Co.
Grinnell Company, Inc.
Hart & Crouse Co.
Honeywell Heating Specialties Co.
International Heater Co.
Kewanee Boiler Co.
Mueller Co.
Modine Mfg. Co.
National Radiator Co.
Neptune Meter Co.
Newport Boiler Co.
Page, Wm. H., Boiler Co.
Patterson-Kelley Co.
Prox, Frank, Co.
Reading Heater & Supply Co.
Richardson & Boynton Co.
Richmond Radiator Co.
Smith, H. B., Co.
Spencer Heater Co.
Thatcher Co., The
U. S. Radiator Corp.
York Heating & Ventilating Corp.

Steam
American Blower Co.
Barnes & Jones
Bishop & Babcock Sales Co., The
Buffalo Forge Co.
Burnham Boiler Corp.
Carrier Engineering Corp.
Dunham, C. A., Co.
Fitzgibbons Boiler Co.
Grinnell Company, Inc.
Hart & Crouse Co.

Hoffman Specialty Co., Inc.
Illinois Engineering Co.
International Heater Co.
Kewanee Boiler Co.
Kieley & Mueller, Inc.
McAlear Mfg. Co.
Marsh, Jas. P., & Co.
Modine Mfg. Co.
National Radiator Co.
Newport Boiler Co.
O-E Specialty Mfg. Co.
Page, Wm. H., Boiler Co.
Pecco, Inc.
Richardson & Boynton Co.
Richmond Radiator Co.
Sarco Co., Inc.
Smith, H. B., Co.
Spencer Heater Co.
Stickle Steam Specialties Co.
Thatcher Co., The
Trane Co.
U. S. Radiator Corp.
Warren Webster & Co.
Wing, L. J., Mfg. Co.
York Heating & Ventilating Corp.

Steam (*Exhaust*)
American Blower Co.
Barnes & Jones
Bishop & Babcock Sales Co., The
Buffalo Forge Co.
Carrier Engineering Corp.
Dunham, C. A., Co.
Grinnell Company, Inc.
Hoffman Specialty Co.
Illinois Engineering Co.
Marsh, Jas. P., & Co.
McAlear Mfg. Co.
Modine Mfg. Co.
O-E Specialty Mfg. Co.
Page, Wm. H., Boiler Co.
Patterson-Kelley Co.
Sarco Co., Inc.
Smith, H. B., Co.
Stickle Steam Specialties Co.
Trane Co.
Warren Webster & Co.
York Heating & Ventilating Corp.

Steam (*Vacuum*)
American Blower Co.
Barnes & Jones
Bishop & Babcock Sales Co., The
Burnham Boiler Corp.
Carrier Engineering Corp.
Dunham, C. A., Co.
Grinnell Company, Inc.
Hoffman Specialty Co.
Illinois Engineering Co.
McAlear Mfg. Co.
Marsh, Jas. P., & Co.
Modine Mfg. Co.
Monash-Younker Co.
Mueller Co.
Nash Engineering Co.
Newport Boiler Co.
O-E Specialty Mfg. Co.
Page, Wm. H., Boiler Co.
Sarco Co., Inc.
Smith, H. B., Co.
Spencer Heater Co.
Stickle Steam Specialties Co.
Sturtevant, B. F., Co.
Trane Co.
U. S. Radiator Corp.
Warren Webster & Co.
York Heating & Ventilating Corp.

Steam (*Vapor*)
Barnes & Jones
Bishop & Babcock Sales Co., The
Burnham Boiler Corp.
Carrier Engineering Corp.
Dunham, C. A., Co.
Grinnell Company, Inc.
Hart & Crouse Co.
Hoffman Specialty Co.
Illinois Engineering Co.
International Heater Co.
Kewanee Boiler Co.
McAlear Mfg. Co.
Marsh, Jas. P., & Co.
Modine Mfg. Co.
National Radiator Co.
Newport Boiler Co.
O-E Specialty Mfg. Co.
Page, Wm. H., Boiler Co.
Pecco, Inc.
Richardson & Boynton Co.
Richmond Radiator Co.
Sarco Co., Inc.
Smith, H. B., Co.
Spencer Heater Co.
Stickle Steam Specialties Co.
Thatcher Co., The
Trane Co.
U. S. Radiator Corp.
Warren Webster & Co.
Wing, L. J., Mfg. Co.
York Heating & Ventilating Corp.

Warm-Air
American Blower Co.
Art Metal Radiator Cover Co.
Buffalo Forge Co.
Carrier Engineering Corp.
Hart & Crouse Co.
International Heater Co.
Langenberg Mfg. Co.
Modine Mfg. Co.
New York Blower Co.
Pecco, Inc.
Skinner Bros. Mfg. Co., Inc.
Sturtevant, B. F., Co.
Thatcher Co., The

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 Company, Inc.

HUMIDIFIERS
American Blower Co.
Art Metal Radiator Cover Co.
Atmospheric Conditioning Corp.
Bishop & Babcock Sales Co., The
Buffalo Forge Co.
Call, John, Co., The
Carrier Engineering Corp.
Cooling and Air Conditioning Corp.
Cooling Tower Co.
Drying Systems, Inc.
Grinnell Company, Inc.
Ilg Electric Ventilating Co.
Johnson Service Co.
Langenberg Mfg. Co.
Midwest Air Filters, Inc.
Modine Mfg. Co.
New York Blower Co.
Pecco, Inc.
Powers Regulator Co.
Reed Air Filter Co.
Skinner Bros. Mfg. Co., Inc.
Spray Engineering Co.
Sturtevant, B. F., Co.

HUMIDITY CONTROL
American Blower Co.
American Radiator Co.
American Schaeffer & Budenberg Corp.
Atmospheric Conditioning Corp.
Bishop & Babcock Sales Co., The
Carrier Engineering Corp.
Cooling and Air Conditioning Corp.
Cooling Tower Co.
Drying Systems, Inc.
Grinnell Company, Inc.
Johnson Service Co.
Klipfel Mfg. Co.
Midwest Air Filters, Inc.
Modine Mfg. Co.
New York Blower Co.
Pecco, Inc.
Powers Regulator Co.
Sarco Co., Inc.
Spray Engineering Co.
Skinner Bros. Mfg. Co., Inc.
Sturtevant, B. F., Co.
Taylor Instrument Companies

INCINERATORS, Hot Water (*See Heaters, Water, Incinerator*)

INSTRUMENTS—Air Testing (*See Air Testing Instruments*)

Indicating
American Schaeffer & Budenberg Corp.
Combustion Specialties Corp.
Ellison, Lewis M.
Hays Corp., The
Hill, E. Vernon, Co.
Marsh, Jas. P., & Co.
Taylor Instrument Companies

Recording
American Schaeffer & Budenberg Corp.
Hays Corp., The
Marsh, Jas. P., & Co.
Taylor Instrument Companies

INSULATING LUMBER
Celotex Co.

INSULATING MATERIALS (*See Asbestos and Insulating Products*)

Cold
Celotex Co.
Johns-Manville, Inc.
Universal Gypsum & Lime Co.

Heat
Celotex Co.
Johns-Manville, Inc.
Ric-wil Co.
Universal Gypsum & Lime Co.

Sound Deadening
Cork Foundation Co.
Korfund Co., The

JOINTS—Expansion
Alberger Heater Co.
Badger, E. B., & Sons Co.
Fulton Co.
Illinois Engineering Co.
Mogul Machine Co.
Warren Webster & Co.

Pipe
Grinnell Company, Inc.

KILNS, DRY
American Blower Co.
Buffalo Forge Co.
Carrier Engineering Corp.
Drying Systems, Inc.
New York Blower Co.
Sturtevant, B. F., Co.

LIQUID, BOILER (*See Boiler Liquid*)

MACHINES, REFRIGERATING (*See Refrigerating Machinery*)

MAGNESIA PRODUCTS (*See Asbestos and Insulating Products*)

MECHANICAL DRAFT APPARATUS
American Blower Co.
Buffalo Forge Co.
Carrier Engineering Corp.
Clarage Fan Co.
Combustion Specialties Corp.
Hays Corp., The
Ilg Electric Ventilating Co.
Kieley & Mueller, Inc.
Mason Regulator Co.
New York Blower Co.
Sturtevant, B. F., Co.
Taylor Instrument Companies
Wing, L. J., Mfg. Co.

METAL WEATHER STRIPS (*See Weather Strips, Metal*)

METERS—Feed Water
Johns-Manville, Inc.

Flow
Spray Engineering Co.

Water
Johns-Manville, Inc.
Neptune Meter Co.
Worthington Pump & Machinery Corp.

MICA
Westinghouse Electric & Mfg. Co.

MOISTENERS, AIR (*See Humidifiers*)

MOTOR CONTROLLERS (*See Controllers, Motor*)

MOTORS—Electric
Honeywell Heating Specialties
Ilg Electric Ventilating Co.
Johnson Service Co.
Sturtevant, B. F., Co.
Westinghouse Electric & Mfg. Co.

NOZZLES—Brine Spray
Atmospheric Conditioning Corp.
Badger, E. B., & Sons Co.
Buffalo Forge Co.
Cooling Tower Co.
Spray Engineering Co.

Spray
American Blower Co.
Atmospheric Conditioning Corp.
Badger, E. B., & Sons Co.
Bayley Mfg. Co.
Buffalo Forge Co.
Carrier Engineering Co.
Clarage Fan Co.
Cooling Tower Co.
New York Blower Co.
Spray Engineering Co.
Sturtevant, B. F., Co.
Warren Webster Co.

OIL BURNERS
American NoKol Co.
Automatic Burner Corp.
Ballard Oil Equioment Co.
Johnson, S. T., Co.
Winslow Boiler & Engineering Co.

ORSATS
Hays Corp., The

PACKING—Asbestos
Jenkins Bros.
Johns-Manville, Inc.
New York Blower Co.

Metallic
Johns-Manville, Inc

Rubber
Jenkins Bros.
Johns-Manville, Inc.

PIPE—Bending
Badger, E. B., & Sons Co.
Grinnell Company, Inc.

Cast Iron
Grinnell Company, Inc.

Coils (*See Coils, Pipe*)

Covering (*See Covering, Pipe and Tank; also, Conduits*)

Fittings
Grinnell Company, Inc.
Westinghouse Electric & Mfg. Co.

Hangers (*See Hangers, Pipe*)

Joint Cement (*See Cement, Pipe Joint*)

Plugs (*See Plugs, Pipe*)

Wrought Iron and Steel
Grinnell Company, Inc.

PIPELESS FURNACES (*See Furnaces, Pipeless*)

PITOT TUBES AND GAGES
Clarage Fan Co.
Hays Corp., The
Higgin Mfg. Co.
Hill, E. Vernon, Co.

PLATES—Floor
American Radiator Co.
Grinnell Company, Inc.
Modern Mfg. Co.
National Radiator Co.

PLUGS—Fusible
Grinnell Company, Inc.

Pipe
Grinnell Company, Inc.

POWER PLANT SUPPLIES
American Blower Co.
American Radiator Co.
American Schaeffer & Budenberg Corp.
Buffalo Forge Co.
Cooling Tower Co.
Davis, G. M., Regulator Co.
Dunham, C. A., Co.
Grinnell Company, Inc.
Illinois Engineering Co.
Johns-Manville, Inc.
Kieley & Mueller, Inc.
Klipfel Mfg. Co.
McAlear Mfg. Co.
Mason Regulator Co.
Sarco Co., Inc.
Sturtevant, B. F., Co.
Taylor Instrument Companies
Westinghouse Electric & Mfg. Co.

PRESSURE GAGES (*See Gages, Pressure*)

PROTECTORS—Radiator
American Radiator Co.
Art Metal Radiator Cover Co.
Dixie Metal Products Co., Inc.
Fulton Co.
Modine Mfg. Co.
U. S. Radiator Corp.

PSYCHROMETERS
Grinnell Company, Inc.
Higgin Mfg. Co.
Hill, E. Vernon, Co.
Taylor Instrument Companies

PUBLICATIONS
American Society of Heating and Ventilating Engineers
Heating & Ventilating Magazine
Hill, E. Vernon, Co.
Warren Webster & Co.

PUMPS—Air
Bishop & Babcock Sales Co., The
Buffalo Steam Pump Co.
Chicago Pump Co.
Economy Pumping Machinery Co.
McAlear Mfg. Co.
Nash Engineering Co.
O-E Specialty Mfg. Co.
Powers Regulator Co.
Trane Co.
Worthington Pump & Machinery Corp.

Automatic Electric
Chicago Pump Co.
Economy Pumping Machinery Co.
Gould Pumps, Inc.
Nash Engineering Co.
Trane Co.
Westinghouse Electric & Mfg. Co.
Worthington Pump & Machinery Corp.
Yeomans Brothers Co.
Young Pump Co.

Boiler Feed
Buffalo Steam Pump Co.
Chicago Pump Co.
Economy Pumping Machinery Co.
Goulds Pumps, Inc.
Nash Engineering Co.
O-E Specialty Mfg. Co.
Skidmore Corp.
Trane Co.
Worthington Pump & Machinery Corp.
Yeomans Brothers Co.
Young Pump Co.

Centrifugal
Buffalo Steam Pump Co.
Chicago Pump Co.
Economy Pumping Machinery Co.
Goulds Pumps, Inc.
Nash Engineering Co.
Skidmore Corp.
Trane Co.
Worthington Pump & Machinery Corp.
Yeomans Brothers Co.
Young Pump Co.

Circulating
Chicago Pump Co.
Economy Pumping Machinery Co.
Goulds Pumps, Inc.
Nash Engineering Co.
Trane Co.
Worthington Pump & Machinery Corp.
Yeomans Brothers Co.

Condensation
Buffalo Steam Pump Co.
Chicago Pump Co.
Economy Pumping Machinery Co.
Goulds Pumps, Inc.
Nash Engineering Co.
O-E Specialty Mfg. Co.
Skidmore Corp.
Trane Co.
Worthington Pump & Machinery Corp.
Yeomans Brothers Co.
Young Pump Co.

Electric
Buffalo Steam Pump Co.
Chicago Pump Co.
Economy Pumping Machinery Co.
Goulds Pumps, Inc.
Nash Engineering Co.
Skidmore Corp.
Trane Co.
Westinghouse Electric & Mfg. Co.
Worthington Pump & Machinery Corp.
Yeomans Brothers Co.
Young Pump Co.

Rotary
Buffalo Steam Pump Co.
Chicago Pump Co.
Economy Pumping Machinery Co.
Goulds Pumps, Inc.
Nash Engineering Co.
Worthington Pump & Machinery Corp.

Steam
Buffalo Steam Pump Co.
Nash Engineering Co.
Worthington Pump & Machinery Corp.

Sump
Buffalo Steam Pump Co.
Chicago Pump Co.
Economy Pumping Machinery Co.
Goulds Pumps, Inc.
Nash Engineering Co.
Trane Co.
Worthington Pump & Machinery Corp.
Yeomans Brothers Co.

Triplex
Goulds Pumps, Inc.

Turbine
Buffalo Steam Pump Co.
Economy Pumping Machinery Co.
Goulds Pumps, Inc.
Nash Engineering Co.
Trane Co.
Westinghouse Electric & Mfg. Co.
Worthington Pump & Machinery Corp.
Yeomans Brothers Co.

Vacuum
Buffalo Forge Co.
Buffalo Steam Pump Co.
Chicago Pump Co.
Economy Pumping Machinery Co.
Goulds Pumps, Inc.
McAlear Mfg. Co.
Nash Engineering Co.
O-E Specialty Mfg. Co.
Skidmore Corp.
Trane Co.
Westinghouse Electric & Mfg. Co.
Worthington Pump & Machinery Corp.
Young Pump Co.

RADIATOR—Air Valves (*See Valves, Air*)

Brackets
American Radiator Co.
Continental Heater Corp.
Grinnell Company, Inc.
Healy-Ruff Co.
Hoffman Specialty Co.
Kewanee Boiler Co.
Modern Mfg. Co.
National Radiator Co.
Pierce, Butler & Pierce Mfg. Co.
Smith, H. B., Co.
U. S. Radiator Corp.
York Heating & Ventilating Corp.

Covers
American Radiator Co.
Art Metal Radiator Cover Co.
Dixie Metal Products Co., Inc.
Reed Air Filter Co.
U. S. Radiator Corp.

ELBOWS (*See Elbows, Radiator*)

ENCLOSURES
Art Metal Radiator Cover Co.
Dixie Metal Products Co., Inc.

Hangers (*See Hangers, Radiator*)

Humidifiers (*See Humidifiers*)

Return Line Valves (*See Valves, Return Line*)

Shields (*See Protectors, Radiator*)

Traps (*See Traps, Radiator*)

Valves (*See Valves, Radiator*)

RADIATORS—Fan System
Aerofin Corp.
American Blower Co.
American Radiator Co.
Buffalo Forge Co.
Modine Mfg. Co.
O-E Specialty Mfg. Co.
Rome-Turney Radiator Co.
Smith, H. B., Co.

Gas
Grinnell Company, Inc.

Hot Water
Aerofin Corp.
American Blower Co.
American Radiator Co.
Bridgeport Rolling Mill Co.
Burnham Boiler Corp.
Continental Heater Corp.
Fowler & Wolfe Mfg. Co.
Ilg Electric Ventilating Co.
Kewanee Boiler Co.
Modine Mfg. Co.
National Radiator Co.
Niagara Radiator & Boiler Co.
O-E Specialty Mfg. Co.
Page, Wm. H., Boiler Co.
Pierce, Butler & Pierce Mfg. Corp.
Richmond Radiator Co.
Rome-Turney Radiator Co.
Smith, H. B., Co.
Sturtevant, B. F., Co.
Thatcher Co., The
U. S. Radiator Corp.
Utica Heater Co.
Weil-McLain Co.
York Heating & Ventilating Corp.

Steam
Aerofin Corp.
American Blower Co.
American Radiator Co.
Bridgeport Rolling Mill Co.
Buffalo Forge Co.
Burnham Boiler Corp.
Continental Heater Corp.
Fowler & Wolfe Mfg. Co.
Kewanee Boiler Co.
Modine Mfg. Co.
National Radiator Co.
Niagara Radiator & Boiler Co.
O-E Specialty Mfg. Co.
Page, Wm. H., Boiler Co.
Pierce, Butler & Pierce Mfg. Corp.
Richmond Radiator Co.
Rome-Turney Radiator Co.
Smith, H. B., Co.
Thatcher Co., The
U. S. Radiator Corp.
Utica Heater Co.
Weil-McLain Co.

Wall
American Radiator Co.
Burnham Boiler Corp.
Continental Heater Corp.
Fowler & Wolfe Mfg. Co.
Kewanee Boiler Co.
Modine Mfg. Co.
National Radiator Co.
Niagara Radiator & Boiler Co.
Page, Wm. H., Boiler Co.
Pierce, Butler & Pierce Mfg. Corp.
Richmond Radiator Co.
Smith, H. B., Co.
U. S. Radiator Corp.
Utica Heater Co.
Weil-McLain Co.

RECEIVERS—Air
Buffalo Steam Pump Co.
Illinois Engineering Co.
Kewanee Boiler Co.
Klipfel Mfg. Co.
O-E Specialty Mfg. Co.
Titusville Iron Works
Trane Co.
Whitlock Coil Pipe Co.

Ammonia
Titusville Iron Works
Whitlock Coil Pipe Co.

Condensation
Bishop & Babcock Sales Co., The
Chicago Pump Co.
Davis, G. M., Regulator Co.
Economy Pumping Machinery Co.
Illinois Engineering Co.
Kieley & Mueller, Inc.
Klipfel Mfg. Co.
McAlear Mfg. Co.
Mason Regulator Co.
Nash Engineering Co.
Titusville Iron Works
Trane Co.

REFRIGERATING MACHINERY

Carrier Engineering Corp.
Cooling Tower Co.
Worthington Pump & Machinery Corp.

REFRIGERATING SECTIONS

American Radiator Co.

REGISTERS AND GRILLES

Art Metal Radiator Cover Co.
Dixie Metal Products Co., Inc.
Knowles Mushroom Ventilator Co.
Modine Mfg. Co.
Sturtevant, B. F., Co.

REGULATORS—Damper

American Radiator Co.
Bishop & Babcock Sales Co., The
Burnham Boiler Corp.
Carrier Engineering Corp.
D. & T. Mfg. Co.
Dunham, C. A., Co.
Fulton Co.
Hoffman Specialty Co., Inc.
Honeywell Heating Specialties Co.
Illinois Engineering Co.
Kieley & Mueller, Inc.
Klipfel Mfg. Co.
McAlear Mfg. Co.
Marsh, Jas. P., & Co.
Mason Regulator Co.
Minneapolis Heat Regulator Co.
Mouat Vapor Heating Co.
Mueller Co.
National Radiator Co.
Herman Nelson Corp.
O-E Specialty Mfg. Co.
Powers Regulator Co.
Sarco Co., Inc.
Stickle Steam Specialties Co.
Taylor Instrument Companies
Trane Co.
U. S. Radiator Corp.
Warren Webster & Co.
Wing, L. J., Mfg. Co.
York Heating & Ventilating Corp.

Feed Water

American Radiator Co.
American Schaeffer & Budenberg Corp.
Davis, G. M., Regulator Co.
Jenkins Bros.
Kieley & Mueller, Inc.
McAlear Mfg. Co.
McDonnell & Miller
Sarco Co., Inc.
Stickle Steam Specialties Co.
Taylor Instrument Companies
Warren Webster & Co.

Humidity

American Radiator Co.
American Schaeffer & Budenberg Corp.
Art Metal Radiator Cover Co.
Carrier Engineering Corp.
Grinnell Company, Inc.
Johnson Service Co.
Klipfel Mfg. Co.
Powers Regulator Co.
Taylor Instrument Companies

Pressure

Absolute Con-tac-tor Corp.
American Radiator Co.
American Schaeffer & Budenberg Corp.
Bishop & Babcock Sales Co., The
Davis, G. M., Regulator Co.
Dunham, C. A., Co.
Fulton Co.
Hoffman Specialty Co.
Honeywell Heating Specialties Co.
Illinois Engineering Co.
Johnson Service Co.
Kieley & Mueller, Inc.
Klipfel Mfg. Co.
McAlear Mfg. Co.
Mason Regulator Co.
Mueller Co.
O-E Specialty Mfg. Co.
Powers Regulator Co.
Sarco Co., Inc.
Stickle Steam Specialties Co.
Taylor Instrument Companies

Pump

American Radiator Co.
Bishop & Babcock Sales Co., The
Davis, G. M., Regulator Co.
Dunham, C. A., Co.
Economy Pumping Machinery Co.
Illinois Engineering Co.
Kieley & Mueller, Inc.
Klipfel Mfg. Co.
Mason Regulator Co.
McAlear Mfg. Co.
Mueller Co.
Stickle Steam Specialties Co.
Trane Co., The

Steam

Absolute Con-tac-tor Corp.
American Radiator Co.
American Schaeffer & Budenberg Corp.
Bishop & Babcock Sales Co., The
Davis, G. M., Regulator Co.
Dunham, C. A., Co.
Fulton Co., The
Honeywell Heating Specialties Co.
Illinois Engineering Co.
Jenkins Bros.
Kieley & Mueller, Inc.
Klipfel Mfg. Co.
Mason Regulator Co.
McAlear Mfg. Co.
Mueller Co.
Powers Regulator Co.
Sarco Co., Inc.
Stickle Steam Specialties Co.
Taylor Instrument Companies
Trane Co.
U. S. Radiator Corp.
Warren Webster & Co.
Wing, L. J., Mfg. Co.

Temperature

Absolute Con-tac-tor Corp.
American Radiator Co.
American Schaeffer & Budenberg Corp.
Bishop & Babcock Sales Co., The
Burnham Boiler Corp.
Carrier Engineering Corp.
D. & T. Mfg. Co.
Fulton Co.
Honeywell Heating Specialties Co.
Illinois Engineering Co.
Johnson Service Co.
Kieley & Mueller, Inc.
Klipfel Mfg. Co.
Minneapolis Heat Regulator Co.
National Radiator Co.
O-E Specialty Mfg. Co.
Powers Regulator Co.
Reading Heater & Supply Co.
Sarco Co., Inc.
Stickle Steam Specialties Co.
Taylor Instrument Companies
U. S. Radiator Corp.
Westinghouse Electric & Mfg. Co.

Vacuum

Absolute Con-tac-tor Corp.
American Radiator Co.
Bishop & Babcock Sales Co., The
Chicago Pump Co.
Davis, G. M., Regulator Co.
Dunham, C. A., Co.
Economy Pumping Machinery Co.
Hoffman Specialty Co.
Honeywell Heating Specialties Co.
Illinois Engineering Co.
Kieley & Mueller, Inc.
Klipfel Mfg. Co.
McAlear Mfg. Co.
Mason Regulator Co.
Mueller Co.
National Radiator Co.
O-E Specialty Mfg. Co.
Stickle Steam Specialties Co.
Trane Co.
U. S. Radiator Corp.
Warren Webster & Co.

Vapor

Absolute Con-tac-tor Corp.
American Radiator Co.
Bishop & Babcock Sales Co., The
Davis, G. M., Regulator Co.
Dunham, C. A., Co.
Hoffman Specialty Co., Inc.
Honeywell Heating Specialties Co.
Illinois Engineering Co.
Kieley & Mueller, Inc.
Klipfel Mfg. Co.
McAlear Mfg. Co.
Mason Regulator Co.
Minneapolis Heat Regulator Co.
Mouat Vapor Heating Co.
Herman Nelson Corp.
O-E Specialty Mfg. Co.
Powers Regulator Co.
Trane Co.
U. S. Radiator Corp.

Water

American Radiator Co.
American Schaeffer & Budenberg Corp.
Bishop & Babcock Sales Co., The
Davis, G. M., Regulator Co.
Fulton Co.
Honeywell Heating Specialties Co.
Jenkins Bros.
Kieley & Mueller, Inc.
Klipfel Mfg. Co.
McAlear Mfg. Co.
Mason Regulator Co.
Minneapolis Heat Regulator Co.
Mueller Co.
Powers Regulator Co.
Reading Heater & Supply Co.
Taylor Instrument Companies
U. S. Radiator Corp.

Water Level (*See Controllers*)

REHEATERS—Air

Aerofin Corp.
American Blower Co.
American Radiator Co.
Buffalo Forge Co.
Ilg Electric Ventilating Co.
New York Blower Co.
Stickle Steam Specialties Co.
Sturtevant, B. F., Co.
York Heating & Ventilating Corp.

RELAY SWITCHES (*See Switches, Control and Relay*)

ROOF VENTILATORS (*See Ventilators, Roof*)

ROTARY DRYERS (*See Drying Apparatus*)

ROTARY HACK SAW TOOLS

Excelso Specialty Works, Inc.

SCALE REMOVER—Boiler

No Rad Rust Corp.
O-E Specialty Mfg. Co.
Vinco Co.
"X" Laboratories

SCRUBBERS, AIR

American Blower Co.
Buffalo Forge Co.

SEPARATORS—Dust

American Blower Co.
Buffalo Forge Co.
Call, John, Co., The
Carrier Engineering Corp.
New York Blower Co.
Pecco, Inc.
Sturtevant, B. F., Co.
York Heating & Ventilating Corp.

Steam and Oil

Bishop & Babcock Sales Co., The
Dunham, C. A., Co.
Illinois Engineering Co.
Kieley & Mueller, Inc.
McAlear Mfg. Co.
Patterson-Kelley Co.
Stickle Steam Specialties Co.
Warren Webster & Co.

SHEETS—Asbestos

Johns-Manville, Inc.
New York Blower Co.

SHIELDS (*See Protectors, Radiator*)

SHOWER BATH CONTROLLERS (*See Controllers, Shower Bath*)

SMOKE CONSUMER

Combustion Specialties Corp.
Hays Corp., The
Universal Smokeless Boiler Co.

SOFTENERS, WATER (*See Water Softeners*)

SPECIALTIES, HEATING (*See Heating Specialties*)

SPECIALTIES—Sheet Metal

Call, John, Co., The
Sturtevant, B. F., Co.
York Heating & Ventilating Corp.

SPECIALTIES, STEAM (*See Steam Specialties*)

SPRAY COOLING SYSTEMS

American Blower Co.
Atmospheric Conditioning Corp.
Badger, E. B., & Sons Co.
Buffalo Forge Co.
Carrier Engineering Corp.
Cooling Tower Co.
New York Blower Co.
Spray Engineering Co.

SPRAY NOZZLES (*See Nozzles, Spray*)

STEAM CALORIMETERS (*See Calorimeters, Steam*)

STEAM ENGINES (*See Engines, Steam*)

STEAM HEATING SYSTEMS (*See Heating Systems, Steam*)

STEAM SPECIALTIES

Absolute Con-tac-tor Corp.
American Radiator Co.
American Schaeffer & Budenberg Corp.
Barnes & Jones
Bishop & Babcock Sales Co., The
Davis, G. M., Regulator Co.
Dunham, C. A., Co.
Fulton Co.
Hays Corp., The
Hoffman Specialty Co.
Illinois Engineering Co.
Johns-Manville, Inc.
Kieley & Mueller, Inc.
Klipfel Mfg. Co.
McAlear Mfg. Co.
Marsh, Jas. P., & Co.
Mason Regulator Co.
O-E Specialty Mfg. Co.
Powers Regulator Co.
Sarco Co., Inc.
Stickle Steam Specialties Co.
U. S. Radiator Corp.
Trane Co.
Warren Webster & Co.

STOKERS

Riley Stoker Corp.
Sturtevant, B. F., Co.
Westinghouse Electric & Mfg. Co.

Pulverized

CoKal Co.
Riley Stoker Corp.

STRAINERS—Oil

CoKal Co.
Davis, G. M., Regulator Co.
Illinois Engineering Co.
Kieley & Mueller, Inc.
McAlear Mfg. Co.
Mason Regulator Co.
Mueller Co.
Sarco Co., Inc.

Steam

Bishop & Babcock Sales Co., The
Davis, G. M., Regulator Co.
Illinois Engineering Co.
Kieley & Mueller, Inc.
McAlear Mfg. Co.
Mason Regulator Co.
Mueller Co.
Sarco Co., Inc.

Water

Davis, G. M., Regulator Co.
Dunham, C. A., Co.
Illinois Engineering Co.
Kieley & Mueller, Inc.
McAlear Mfg. Co.
Mason Regulator Co.
Mueller Co.
Sarco Co., Inc.
Spray Engineering Co.

SUPPLIES—Power Plant (*See Power Plant Supplies*)

SUPPORTS (*See Hangers, Pipe and Radiator*)

SWITCHES—Control-Relay

McDonnell & Miller
Minneapolis Heat Regulator Co.
Powers Regulator Co.
Trane Co.
Westinghouse Electric & Mfg. Co.

Safety

Westinghouse Electric & Mfg. Co.

SYSTEMS—Domestic Hot Water

Absolute Con-tac-tor Corp.
Excelso Specialty Works, Inc.
Honeywell Heating Specialties Co.
International Heater Co.
Smith, H. B., Co.
Spray Engineering Co.
Spencer Heater Co.
U. S. Radiator Corp.

Dust Collecting

American Blower Co.
Buffalo Forge Co.
Call, John, Co., The
Carrier Engineering Corp.
Clarage Fan Co.
Cooling Tower Co., Inc.
Midwest Air Filters, Inc.
New York Blower Co.
Pecco, Inc.
Reed Air Filter Co.
Skinner Bros. Mfg. Co., Inc.
Spray Engineering Co.
Sturtevant, B. F., Co.
York Heating & Ventilating Corp.

Exhaust (*See Exhaust Systems*)

Hot Blast

Absolute Con-tac-tor Corp.
Aerofin Corp.
American Blower Co.
Buffalo Forge Co.
Carrier Engineering Corp.
Clarage Fan Co.
Ilg Electric Ventilating Co.
Langenberg Mfg. Co.
Modine Mfg. Co.
New York Blower Co.
O-E Specialty Mfg. Co.
Pecco, Inc.
Sturtevant, B. F., Co.
York Heating & Ventilating Corp.

Spray Cooling (*See Spray Cooling Systems*)

Temperature Control

Absolute Con-tac-tor Corp.
American Blower Co.
American Radiator Co.
American Schaeffer & Budenberg Corp.
Bishop & Babcock Sales Co., The
Buffalo Forge Co.
Carrier Engineering Corp.
Clarage Fan Co.
Fulton Co.
Honeywell Heating Specialties Co.
Illinois Engineering Co.
Johnson Service Co.
Kieley & Mueller, Inc.
Klipfel Mfg. Co.
Mueller Co.
Powers Regulator Co.
Sarco Co., Inc.
Sturtevant, B. F., Co.
Taylor Instrument Companies

Ventilating (*See Ventilating Systems*)

TANK—Coils (*See Coils, Tank*)

Covering (*See Covering, Pipe and Tank*)

Heaters (*See Heaters, Tank*)

Regulators
Absolute Con-tac-tor Corp.
American Radiator Co.
American Schaeffer & Budenberg Corp.
Bishop & Babcock Sales Co., The
Davis, G. M., Regulator Co.
Fulton Co.
Johnson Service Co.
Kieley & Mueller, Inc.
Klipfel Mfg. Co.
McAlear Mfg. Co.
Mason Regulator Co.
Minneapolis Heat Regulator Co.
Mueller Co.
Page, Wm. H., Boiler Co.
Powers Regulator Co.
Sarco Co., Inc.
Stickle Steam Specialties Co.
Taylor Instrument Companies

TANKS—Blow-Off
Economy Pumping Machinery Co.
Lebanon Boiler Works
Oil City Boiler Works
Petty, J. K., & Co., Inc.
Titusville Iron Works

Cast Iron
Bishop & Babcock Sales Co., The
Economy Pumping Machinery Co.

Pressure
Ames Iron Works
American Schaeffer & Budenberg Corp.
Harrisburg Star Boiler Corp.
Kewanee Boiler Co.
Kieley & Mueller, Inc.
Klipfel Mfg. Co.
Lebanon Boiler Works
Oil City Boiler Works
Petty, J. K., & Co., Inc.
Titusville Iron Works

Storage
Ames Iron Works
Frank, O. E., Heater & Engineering Co.
Harrisburg Star Boiler Corp.
Kewanee Boiler Co.
Lebanon Boiler Works
National Radiator Co.
Oil City Boiler Works
Page, Wm. H., Boiler Co.
Patterson-Kelley Co.
Petty, J. K., & Co., Inc.
Titusville Iron Works

TEMPERATURE REGULATORS (*See Regulators, Temperature*)

THERMOMETERS
American Radiator Co.
American Schaeffer & Budenberg Corp.
Bishop & Babcock Sales Co., The
Burnham Boiler Corp.
Hays Corp., The
Hill, E. Vernon, Co.
Marsh, Jas. P., & Co.
National Radiator Co.
Pierce, Butler & Pierce Mfg. Corp.
Powers Regulator Co.
Taylor Instrument Companies
U. S. Radiator Corp.

THERMOSTATS
Absolute Con-tac-tor Corp.
American Radiator Co.
American Schaeffer & Budenberg Corp.
Bishop & Babcock Sales Co., The
Burnham Boiler Corp.
Fulton Co.
Honeywell Heating Specialties Co.
Johnson Service Co.
Kieley & Mueller, Inc.
Klipfel Mfg. Co.
Powers Regulator Co.
Sarco Co., Inc.
Taylor Instrument Companies
Westinghouse Electric & Mfg. Co.

TRAPS—Air Blast
Grinnell Company, Inc.

Float
Barnes & Jones
Davis, G. M., Regulator Co.
Dunham, C. A., Co.
Hoffman Specialty Co., Inc.
Illinois Engineering Co.
Sarco Co., Inc.
Trane Co.

Radiator
Barnes & Jones
Bishop & Babcock Sales Co., The
Dunham, C. A., Co.
Hoffman Specialty Co., Inc.
Illinois Engineering Co.
Johns-Manville, Inc.
McAlear Mfg. Co.
Marsh, Jas. P., & Co.
Monash-Younker Co., Inc.
Mouat Vapor Heating Co.
Mueller Co.
National Radiator Co.
O-E Specialty Mfg. Co.
Sarco Co., Inc.
Stickle Steam Specialties Co.
Trane Co.
U. S. Radiator Corp.
Warren Webster & Co.

Return
American Blower Co.
Barnes & Jones
Bishop & Babcock Sales Co., The
Dunham, C. A., Co.
Hoffman Specialty Co.
Illinois Engineering Co.
Johns-Manville, Inc.
Kieley & Mueller, Inc.
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Mouat Vapor Heating Co.
O-E Specialty Mfg. Co.
Sarco Co., Inc.
Trane Co.
U. S. Radiator Corp.
Warren Webster & Co.

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Marsh, Jas. P., & Co.

Steam
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American Schaeffer & Budenberg Corp.
Barnes & Jones
Bishop & Babcock Sales Co., The
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Dunham, C. A., Co.
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Reading Heater & Supply Co.
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Stickle Steam Specialties Co.
Sturtevant, B. F., Co.
U. S. Radiator Corp.
Warren Webster & Co.

Thermostatic
Dunham, C. A., Co.

Vacuum
American Blower Co.
Barnes & Jones
Bishop & Babcock Sales Co., The
Dunham, C. A., Co.
Hoffman Specialty Co., Inc.
Illinois Engineering Co.
Johns-Manville, Inc.
Kieley & Mueller, Inc.
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O-E Specialty Mfg. Co.
Sarco Co., Inc.
Stickle Steam Specialties Co.
Trane Co.
U. S. Radiator Corp.
Warren Webster & Co.

TURBINES—Steam
Sturtevant, B. F., Co.
Westinghouse Electric & Mfg. Co.
Wing, L. J., Mfg. Co.

TURBO-BLOWERS
American Blower Co.
Buffalo Forge Co.
New York Blower Co.
Sturtevant, B. F., Co.
Wing, L. J., Mfg. Co.

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Nash Engineering Co.
Sturtevant, B. F., Co.

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VALVES—Air
American Radiator Co.
American Schaeffer & Budenberg Corp.
Bishop & Babcock Sales Co., The
Burnham Boiler Corp.
Davis, G. M., Regulator Co.
Dole Valve Co., The
Dunham, C. A., Co.
Fulton Co.
Healy-Ruff Co.
Hoffman Specialty Co., Inc.
Jenkins Bros.
Kieley & Mueller, Inc.

Klipfel Mfg. Co.
McAlear Mfg. Co.
Marsh, Jas. P., & Co.
Monash-Younker Co., Inc.
Mueller Co.
National Radiator Co.
O-E Specialty Mfg. Co.
Page, Wm. H., Boiler Co.
Pierce, Butler & Pierce Mfg. Corp.
Powers Regulator Co.
Smith, H. B., Co.
Trane Co.
U. S. Radiator Corp.

Angle, Check and Globe
American Radiator Co.
Davis, G. M., Regulator Co.
Dole Valve Co., The
Grinnell Company, Inc.
Illinois Engineering Co.
Jenkins Bros.
Marsh Valve Co.
McAlear Mfg. Co.
National Radiator Co.
O-E Specialty Mfg. Co.
Pierce, Butler & Pierce Mfg. Corp.
Powers Regulator Co.
U. S. Radiator Corp.

Back-Pressure
Bishop & Babcock Sales Co., The
Davis, G. M., Regulator Co.
Illinois Engineering Co.
Jenkins Bros.
Kieley & Mueller, Inc.
Klipfel Mfg. Co.
McAlear Mfg. Co.
O-E Specialty Mfg. Co.
Stickle Steam Specialties Co.

Blow-Off
Davis, G. M., Regulator Co.
Jenkins Bros.
Mueller Co.
U. S. Radiator Corp.

Float
American Radiator Co.
Davis, G. M., Regulator Co.
Illinois Engineering Co.
Kieley & Mueller, Inc.
Klipfel Mfg. Co.
McAlear Mfg. Co.
Mason Regulator Co.
O-E Specialty Mfg. Co.
Stickle Steam Specialties Co.
Trane Co.

Gage
Bishop & Babcock Sales Co., The
Grinnell Company, Inc.
O-E Specialty Mfg. Co.
Stickle Steam Specialties Co.
U. S. Radiator Corp.

Gate
American Radiator Co.
Dole Valve Co., The
Jenkins Bros.
Marsh, Jas. P., & Co.
Marsh Valve Co.
National Radiator Co.
O-E Specialty Mfg. Co.

Graduating
American Radiator Co.
Barnes & Jones
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Dole Valve Co., The
Dunham, C. A., Co.
Hoffman Specialty Co., Inc.
Illinois Engineering Co.
Jenkins Bros.
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Monash-Younker Co., Inc.
Mouat Vapor Heating Co.
National Radiator Co.
O-E Specialty Mfg. Co.
Sarco Co., Inc.
Trane Co.
U. S. Radiator Corp.

Hot Water
American Radiator Co.
American Schaeffer & Budenberg Corp.
Barnes & Jones
Burnham Boiler Corp.
Davis, G. M., Regulator Co.
Dole Valve Co., The
Jenkins Bros.
Marsh, Jas. P., & Co.
Marsh Valve Co.
National Radiator Co.
Pierce, Butler & Pierce Mfg. Corp.
U. S. Radiator Corp.

Magnetic
Absolute Con-tac-tor Corp.
Minneapolis Heat Regulator Co.

Modulating
American Radiator Co.
Barnes & Jones
Bishop & Babcock Sales Co., The
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Dole Valve Co., The
Dunham, C. A., Co.
Hoffman Specialty Co., Inc.
Illinois Engineering Co.
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Marsh Valve Co.
Monash-Younker Co., Inc.
O-E Specialty Mfg. Co.
Pierce, Butler & Pierce Mfg. Corp.
Sarco Co., Inc.
Trane Co.
U. S. Radiator Corp.
Warren Webster & Co.

Packless
American Radiator Co.
Barnes & Jones
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Burnham Boiler Corp.
Davis, G. M., Regulator Co.
Dole Valve Co., The
Dunham, C. A., Co.
Fulton Co.
Illinois Engineering Co.
McAlear Mfg. Co.
Marsh, Jas. P., & Co.
Marsh Valve Co.
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National Radiator Co.
O-E Specialty Mfg. Co.
Pierce, Butler & Pierce Mfg. Corp.
Sarco Co., Inc.
Trane Co.
U. S. Radiator Corp.
Warren Webster & Co.

Radiator
American Radiator Co.
Art Metal Radiator Cover Co.
Barnes & Jones
Bishop & Babcock Sales Co., The
Burnham Boiler Corp.
Davis, G. M., Regulator Co.
Dole Valve Co., The
Dunham, C. A., Co.
Fulton Co.
Hoffman Specialty Co., Inc.
Illinois Engineering Co.
International Heater Co.
Jenkins Bros.
McAlear Mfg. Co.
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Marsh Valve Co.
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O-E Specialty Mfg. Co.
Pierce, Butler & Pierce Mfg. Corp.
Powers Regulator Co.
Sarco Co., Inc.
Trane Co.
U. S. Radiator Corp.
Warren Webster & Co.

Reducing
American Radiator Co.
Bishop & Babcock Sales Co., The
Davis, G. M., Regulator Co.
Dunham, C. A., Co.
Fulton Co.
Illinois Engineering Co.
Jenkins Bros.
Kieley & Mueller, Inc.
Klipfel Mfg. Co.
McAlear Mfg. Co.
Mason Regulator Co.
Mueller Co.
O-E Specialty Mfg. Co.
Powers Regulator Co.
Stickle Steam Specialties Co.
Taylor Instrument Companies

Regrinding
Jenkins Bros.

Relief
American Radiator Co.
American Schaeffer & Budenberg Corp.
Davis, G. M., Regulator Co.
Illinois Engineering Co.
Kieley & Mueller, Inc.
Klipfel Mfg. Co.
McAlear Mfg. Co.
Mueller Co.
Neptune Meter Co.
O-E Specialty Mfg. Co.
Powers Regulator Co.
Stickle Steam Specialties Co.
Titusville Iron Works

Return Line
American Radiator Co.
Barnes & Jones
Bishop & Babcock Sales Co., The
Dunham, C. A., Co.
Fulton Co.
Hoffman Specialty Co., Inc.
Illinois Engineering Co.
Jenkins Bros.
Kieley & Mueller, Inc.
McAlear Mfg. Co.
Marsh, Jas. P., & Co.
Mouat Vapor Heating Co.
National Radiator Co.
O-E Specialty Mfg. Co.
Stickle Steam Specialties Co.
Trane Co.
U. S. Radiator Corp.
Warren Webster & Co.

Safety
American Radiator Co.
American Schaeffer & Budenberg Corp.
Burnham Boiler Corp.
Davis, G. M., Regulator Co.
Jenkins Bros.
Marsh, Jas. P., & Co.
Mueller Co.
National Radiator Co.
O-E Specialty Mfg. Co.
Titusville Iron Works Co.
U. S. Radiator Corp.

Steam Feed
Jenkins Bros.
Kieley & Mueller, Inc.
McAlear Mfg. Co.
O-E Specialty Mfg. Co.

Thermostatic
American Radiator Co.
Barnes & Jones
Bishop & Babcock Sales Co., The
Dole Valve Co., The
Dunham, C. A., Co.
Fulton Co.
Hoffman Specialty Co.
Illinois Engineering Co.
Kieley & Mueller, Inc.
McAlear Mfg. Co.
Marsh, Jas. P., & Co.
Monash-Younker Co., Inc.
O-E Specialty Mfg. Co.
Powers Regulator Co.
Sarco Co., Inc.
Stickle Steam Specialties Co.
Taylor Instrument Companies
Trane Co.

Vacuum
American Radiator Co.
Barnes & Jones
Bishop & Babcock Sales Co., The
Burnham Boiler Corp.
Davis, G. M., Regulator Co.
Dole Valve Co., The
Dunham, C. A., Co.
Hoffman Specialty Co., Inc.
Illinois Engineering Co.
Jenkins Bros.
Klipfel Mfg. Co.
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Sarco Co., Inc.
Stickle Steam Specialties Co.
Titusville Iron Works
Trane Co.
U. S. Radiator Corp.
Warren Webster & Co.

Vapor
American Radiator Co.
Barnes & Jones
Bishop & Babcock Sales Co., The
Burnham Boiler Corp.
Davis, G. M., Regulator Co.
Dole Valve Co., The
Dunham, C. A., Co.
Hoffman Specialty Co.
Illinois Engineering Co.
Jenkins Bros.
McAlear Mfg. Co.
Marsh, Jas. P., & Co.
Marsh Valve Co.
Monash-Younker Co., Inc.
Mouat Vapor Heating Co.
O-E Specialty Mfg. Co.
Sarco Co., Inc.
Stickle Steam Specialties Co.
Trane Co.
U. S. Radiator Corp.

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American Blower Co.
Buffalo Forge Co.
Carrier Engineering Corp.
Clarage Fan Co.
Cooling and Air Conditioning Corp.
Cooling Tower Co., Inc.
Ilg Electric Ventilating Co.
Knowles Mushroom Ventilator Co.
Midwest Air Filters, Inc.
Herman Nelson Corp.
Nesbitt, John J., Co.
New York Blower Co.
O-E Specialty Mfg. Co.
Pecco, Inc.
Skinner Bros. Mfg. Co., Inc.
Sturtevant, B. F., Co.
Westinghouse Electric & Mfg. Co.
Wing, L. J., Mfg. Co.
York Heating & Ventilating Corp.

VENTILATORS—Mushroom
American Blower Co.
Call, John, Co., The
Knowles Mushroom Ventilator Co.
New York Blower Co.
Sturtevant, B. F., Co.

Roof
Buffalo Forge Co.
Call, John, Co., The
Ilg Electric Ventilating Co.
Johns-Manville, Inc.
New York Blower Co.
O-E Specialty Mfg. Co.
Pecco, Inc.
Royal Ventilator Co.
Skinner Bros. Mfg. Co., Inc.
Sturtevant, B. F., Co.
York Heating & Ventilating Corp.

Window
Call, John, Co., The
Sturtevant, B. F., Co.

VENTS—Air
American Radiator Co.
Bishop & Babcock Sales Co., The
Burnham Boiler Corp.
Call, John, Co., The
Dole Valve Co., The
Dunham, C. A., Co.
Fulton Co., The
Higgin Mfg. Co.
Hoffman Specialty Co., Inc.
McAlear Mfg. Co.
Marsh, Jas. P., & Co.
O-E Specialty Mfg. Co.
Sturtevant, B. F., Co.
Trane Co.

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Universal Gypsum & Lime Co., 111 West Washington St., Chicago, Ill.	461
Universal Smokeless Boiler Co., Ravenna, Ohio	378–379
U. S. Radiator Co., 133 East Grand River Ave., Detroit, Mich.	374–377
Utica Heater Co., Utica, N. Y.	380–381
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Warren Webster & Co., 17th and Federal Sts., Camden, N. J.	532
Weil-McLain Co., 641 West Lake St., Chicago, Ill.	382
Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa.	466
Whitlock Coil Pipe Co., Hartford, Conn.	432–433
L. J. Wing Mfg. Co., 663 Hudson St., New York, N. Y.	410–411
Winslow Boiler & Engineering Co., 208 South La Salle St., Chicago, Ill.	392–393
Worthington Pump & Mch. Corp., 115 Broadway, New York, N. Y.	477
"X" Laboratories, 25 West 45th St., New York, N. Y.	387
Yeomans Bros. Co., 1433 Dayton St., Chicago, Ill.	480
York Heating & Ventilating Corp., 1502 Locust St., Philadelphia, Pa.	424–425
Young Pump Co., 450 East Ohio St., Chicago, Ill.	478–479

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AMERICAN SOCIETY *of* HEATING *and* VENTILATING ENGINEERS

1926-1927

Contains Lists of Members Arranged Alphabetically and Geographically also Lists of Officers and Committees, Past Officers and Local Chapter Officers

Corrected to July 1926

Published at the Headquarters of the Society

29 West 39th Street, New York, N. Y.

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AMERICAN SOCIETY *of* HEATING *and* VENTILATING ENGINEERS

1926

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1926-27

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Roll of Membership

AMERICAN SOCIETY *of* HEATING *and* VENTILATING ENGINEERS

1926-27

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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), Htg. and Vtg. Engr., J. Gallivan Co., 153 N. Washington St., and (for mail) 21 Milford St., Boston, Mass.

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.

ACHERSON, Albert R., (1919), Prof. Mech. Engrg., Syracuse University, and (for mail) 601 Eckel Theatre Bldg., 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., 1425 16th St., and Denver Athletic Club, Denver, Colo.

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ADDY, Robert, (1919), Plbg. and Htg. Contractor, 7012 Fort St., W., Detroit, Mich.

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AHLFF, Albert A., (Associate 1918; 1923), Br. Mgr., Spencer Heater Co., 433 Jackson Bldg., and (for mail), 521 Crescent Ave., Buffalo, N. Y.

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ALGER, Richard W., (1911), Vice-Pres. and Treas., (for mail), Marye, Alger & Alger, Inc., Archts., 801-6 Walton Bldg., and 15 Penn Ave., Atlanta, Ga.

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ALLEN, Harry D., (1917), Htg. and Vtg. Contracting., (for mail), Harry D. Allen 2940 W. Lake St., and 1640 N. Tuna Ave., Chicago, Ill.

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ALLING, Harold W., (Junior 1917; Associate 1925), Accountant and Engr., (for mail), Chirnside, Roberts & Langston, 170 Broadway, New York, N. Y., and 529 River St., Hoboken, N. J.

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ALVORD, Arthur M., (1926), Pres., (for mail), Alvord & Swift, Grand Central Terminal, New York, and 240 Hamilton Ave., New Rochelle, N. Y.

AMIRAL, J. H., (Associate 1925), (for mail), Rutzer Htg. Co., 404 East 49th St., New York, and 2713 Voorhees Ave., Brooklyn, N. Y.

AMMERMAN, Charles R., (1916), Consulting Engr., (for mail), 925 Continental Bk. Bldg., and 3908 Guilford Ave., Indianapolis, Ind.

AMSTEIN, Albert W., (1924), Western Dist. Mgr., (for mail), Buckeye Blower Co., 608 S. Dearborn St., and 8314 S. Paulina St., Chicago, Ill.

ANDEL, Frank J., (1922), Pres. and Mgr., Andel & Co., 5062 Pensacola Ave., 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, Claude A., (1916), Dist. Mgr., (for mail), Ilg Elec. Vtg. Co., 325 Commercial Tr. Bldg., Philadelphia, and 5025 Pulaski Ave., Germantown, Pa.
ANDERSON, Edward L., (1921), Asst. Dist. Mgr., (for mail), American Blower Co., 526 Swetland Bldg., Cleveland, and Auraura St., Hudson, O.
ANDERSON, F. Paul,* (1921), (2nd Vice-Pres. 1925; 1st Vice-Pres. 1926, Council 1924-26), Dean, College of Engr., and Prof. Mech. Engr., (for mail), Univ. of Kentucky, and 499 E. Main St., Lexington, Ky.
ANDERSON, H. J., (1919), Whitlock Coil Pipe Co., 149 Broadway, New York, N. Y.
ANDERSON, S. A., Jr., (1909), (for mail), Anderson Bros., 303 Fir St., and P. O. Box 486, 908 North Ave., La Grande, Ore.
ANDRESEN, A. W., (1926), Crane Co., 400 Third Ave., N., and (for mail), 5311 Penn Ave., S., Minneapolis, Minn.
ANGELL, Winfield T., (1922), District Engr., (for mail), Socony Burner Corp., 1130 Main St., Hartford, and Elmwood, Conn.
ANGUS, Harry H., (1918), Consulting Engr., 2 Bloor St., W., and (for mail), 32 Sydney St., Kingston, Ont., Can.
ANGUS, Robert A., (1920), Angus & Ashe, Consulting Engrs., 345 Madison Ave., New York, and 19 Rich Ave., Mt. Vernon, N. Y.
ARCHER, Frank Sibley, (Junior 1926), Sales Engr., (for mail), U. S. Radiator Corp., 303 Crosby Rd., and 12 Amherst St., Rochester, N. Y.
ARENBERG, Milton K., (Associate 1920), Sales Engr., (for mail), Ilg Elec. Vtg. Co., 324 W. Monroe St., and 1380 Hyde Park Blvd., Chicago, 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, Htg. and Vtg. Magazine, 1123 Broadway, New York, N. Y., and 375 Upper Mountain Ave., Upper Montclair, N. J.
ARMSPACH, Otto W.,* (1919), Mech. Engr., (for mail), E. Vernon Hill Co., 64 W. Randolph St., and Villa Park, Chicago, Ill.
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ARONWITS, Wilfred, (Junior 1924; Associate 1925; 1926), Mech. Engr., Leon Stern, Archt. 1017 Commerce Bldg., and (for mail), 1171 Park Ave., Rochester, N. Y.
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ARTHUR, John M., Jr., (1923), Industrial Engr., Kansas City Power & Light Co., Kansas City, Mo., and 3311 State Ave., Kansas City, Kan.
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ATKINSON, Robert E., (1897), (Board of Governors 1907), 6 Trafalgar Rd., Birkdale, Southport, 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), Br. Mgr., (for mail), Natl. Radiator Co., 3032 Norfolk St., Cor. Summit, and 210 W. Graham Rd., Richmond, Va.
AXEMAN, James E., (Junior 1925), Sales Engr., Standard Heater Co., Williamsport, Pa., and (for mail), 25 Portsmouth Terrace, Rochester, N. Y.
AYERS, Archie E., (1921), Member of Firm, (for mail), Rautman Plbg. & Htg. Co., 109 Jackson St., and 3437 Belvedere Ave., Seattle, Wash.

B

BABBITT, Edward C., (1923), Engr., (for mail), Snyder, Babbitt & Mathews, 16 E. Broad St., and 1157 E. Mound St., Columbus, O.
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BACHLER, Harry C., (Junior 1921), Htg. Engr., (for mail), C. F. Bachler & Sons, 139 N. Fourth St., and 836 Kenmore Rd., Philadelphia, Pa.
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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.
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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.
BAIER, Walter P., (Associate 1924), Pres., (for mail), Baier Bros., Inc., 4452 Cass Ave., and 1968 Gladstone Ave., Detroit, Mich.
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BAILEY, Jos. H., (Junior 1923), Carrier Engrg. Corp., 750 Frelinghuysen Ave., Newark, N. J.
BAIN, James G., (1920), Pres., Ideal Specialty Co., P. O. Box 493, Helena, Mont.
BAIRD, F. X., (Associate 1925), 26 Boyden Ave., S. Orange, N. J.
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BAKER, Emerit E., (1910), Pres., Kewanee Boiler Co., Kewanee, Ill.
BAKER, H. W. H., (1918), Sanitary and Htg. Engr., J. Twyford & Co., 20 British Bund, Tientsin, China.
BAKER, Howard C., (1921), Pres., (for mail), The Howard C. Baker Co., 213 Michigan St., and 15 Columbia St., Toledo, O.
BAKER, Irving C., (1921), Dist. Engr., American Blower Co., 614 Bona Allen Bldg., Atlanta, Ga.
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BALDWIN, William H., (1921), Sales Engr., (for mail), C. A. Dunham Co., Ltd., 229 College St., and 600 Windermere Ave., Toronto, Ont., Can.
BAMPTON, C. Morton, (1919), Vice-Pres. and Secy., (for mail), Ideal Htg. Co., 915 Gates Ave., Brooklyn, and 8843 Parkview Ave., Hollis Park Gardens, L. T., 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., and 2403 Madison St., Houston, Tex.

BARNES, Arthur R., (1924), W. E. Hulse & Co., and 24 E. Sixth St., Hutchinson, Kan.
BARR, George W., (1905), Asst. General Sales Mgr., Hoffman Specialty Co., 25 West 45th St., New York, and (for mail), 41 Janvrin Rd., Bronxville, N. Y.
BARRE, Louis S., (1925), Htg. and Sanitary Engr., Garage Central, 67 Rue de France, Tientsin, China.
BARROWS, Charles E., (Associate 1921), Mgr., (for mail), City Sales Dept., Crane Co., 156 N. Jefferson St., Chicago, and Orrington Hotel, Evanston, Ill.
BARRY, Patrick I., (1920), Htg. Engr., M. Barry & Co., 4 Marlboro St., and 2 Clarence Terrace, St. Luke's, Cork, Ireland.
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BARTLETT, Amos C., (1919), N. E. Dist. Mgr., (for mail), B. F. Sturtevant Co., 555 Massachusetts Trust Bldg., Boston, and 10 Dunbarton Rd., Wollaston, Mass.
BARTLETT, Clarence D., (1923), Purchasing Agent, Raisler Htg. Co., 129 Amsterdam Ave., New York, N. Y., and (for mail), 852 Broad St., Bloomfield, N. J.
BARTLETT, C. Edwin, (1922), Pres., Bartlett & Co., Inc., 1938 Market St., Philadelphia, and 209 Creswell St., Ridley Park, Pa.
BARTLEY, John S., Jr., (1924) Archt., (for mail), 903 L. and J. Natl. Bk. Bldg., and 908 Elm St., Waterloo, Ia.
BARTON, Royal Elton, (1922), Engr., (for mail), McLean & Cousens Co., 65 Chandler St., Boston, and Fernald Terrace, Dorchester, Mass.
BARWICK, Thomas, (1920), Consulting Engr., (for mail), Buchman & Kahn, Archts., 49 West 45th St., New York, N. Y., and 408 Rutland Ave., W. Englewood, N. J.
BASSLER, Edwin M., (1923), Gen. Mgr., (for mail), D. J. Murray Mfg. Co., 1002-1024 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.
BATEMAN, William H., Jr., (1921), Htg. Engr., (for mail), C. J. Doyle, 2056 Pine St., and 2519 South 19th St., Philadelphia, Pa.
BAUM, Albert L., (1916), Member of Firm, Jaros & Baum, 116 West 39th St., and (for mail), 562 West 113th St., New York, N. Y.
BAXTER, Robert A., (1923), Sales Engr., (for mail), Utica Heater Co., P. O. Box 44, and 14 Cornelius Ave., Schenectady, N. Y.
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.
BEATTY, David J., (1918), Htg. and Vtg. Engr., (for mail), Chas. Schneider Co., 492 East 163rd St., New York, and 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., 118 East 28th St., New York, N. Y., and 543 Chilton St., Elizabeth, N. J.
BEGGS, Douglas T., (1922), Mgr., (for mail), Wm. Gordon Corp., 516 Bona Allen Bldg., Atlanta, and 612 W. College Ave., Decatur, Ga.
BELING, Earl H., (Junior 1925), Htg. Engr., Warren Webster & Co., 549 W. Washington St., and (for mail), 5604 S. Carpenter St., Chicago, 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., (for mail), American District Steam Co., N. Tonawanda, and 245 Elmwood Ave., Buffalo, N. Y.
BENNITT, George E., (1918), Utilization Dept., Consolidated Gas Co., 130 East 15th St., New York, N. Y.
BENTZ, Harry, (1915), Pres., (for mail), Bentz Engrg. Corp., 661 Frelinghuysen Ave., Newark, and Montclair, N. J.
BERCHTOLD, Edward Wm., (Associate 1925), Industrial Engr., Boston Consolidated Gas Co., 149 Tremont St., Boston, and (for mail), 266 Columbian St., S. Weymouth, Mass.
BERG, A. Herman, (1919), Pres., (for mail), Berg Htg. & Vtg. Co., 754 Laura Ave., and 140 N. Stafford, Huntington Park, Calif.
BERGER, Clyde D., (1922), Gen. Supt. and Mech. Engr., H. E. Crook Co., Inc., Contractors and Engrs., 28 Light St., and 2604 Overland Ave., Baltimore, Md.
BERGHOEFER, Victor A., (Junior 1926), Sales Engr., Sterling Engrg. Co., 1640 Holton St., and 1104 Island Ave., Milwaukee, Wis.
BERGNER, William G., (Associate 1923), Mgr. and Secy., Natl. Trade Extension Bureau; Mercantile Bk. Bldg., and (for mail), 727 Washington Ave., Evansville, Ind.
BERMAN, Louis K., (1908), Secy., (for mail), Raisler Htg. Co., 129 Amsterdam Ave., and 221 West 82nd St., New York, N. Y.
BERRINGER, Sidney H., (1926), Sales Engr., Hoffman Specialty Co., 130 N. Wells St., and (for mail), 1657 Juneway Terrace, Chicago, Ill.
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.
BEYER, Jack E., (Junior 1924), Htg. and Vtg. Engr., The Weiss Htg. & Plbg. Co., 5604 Cedar Ave., and (for mail), 1317 East 112th St., Cleveland, O.
BIDWELL, Raymond E., (Associate 1924), Vice-Pres. and Local Mgr., (for mail), The Kellogg-Mackay Co., 2030 Walnut St., and 7310 Madison, Kansas City, Mo.
BINDER, Charles G., (1920), Mgr. Htg. Dept., Warren Webster & Co., 17th and Federal Sts., Camden, and (for mail), 115 Oak Terrace, Merchantville, N. J.
BINDER, Irving, (Junior 1920; 1922), Estimator, Keasbey & Mattison, 131 Cedar St., 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, Harold A., (Junior 1926), Chief Draftsman, L. H. Prentice Co., 1048-50 W. Van Buren St., and (for mail), 3731 N. Irving Ave., Chicago, Ill.
BIRKHOLZ, H. E., (Associate 1925), Natl. Air Filter Co., 9 S. Clinton St., Chicago, Ill.
BIRRELL, Allan Lloyd, (Associate 1925), Engr., (for mail), Chapman & Oxley, 506 Harbor Commission Bldg., and 201 Pacific Ave., Toronto, Ont., Can.
BISHOP, Charles R., (1901), (Council 1916), Vice-Pres., (for mail), Caloroil Burner Corp., 5 East 40th St., New York, and 413 Locust St., Lockport, N. Y.
BISHOP, Frederick R., (1921), Salesman and Engr., Furnace Dept., Michigan Stove Co., 3306 E. Jefferson Ave., and (for mail), 3780 Carter Ave., Detroit, Mich.
BLACK, Edgar Newbold, 3rd, (1922), Mgr., Kewanee Boiler Co., Inc., 510 Real Estate Trade Bldg., Broad and Chestnut Sts., and (for mail), 1533 Locust St., Philadelphia, Pa.
BLACK, Fred C., (1919), Pres., (for mail), F. C. Black Co., 28 N. Desplaines 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. A., (Junior 1922; Associate 1925), Pres., (for mail), John Black & Son, Inc., 134 Prospect St., and 21 Prospect St., Trenton, N. J.

BLACKHALL, Wilmot R., (1922), Sales Engr., Gurney Foundry Co., Ltd., 500 King St., W., and (for mail), 332 Waverly Rd., Toronto, Ont., Can.

BLACKMAN, Alfred O., (1911), Supt. Power and Plant, (for mail), The Yale & Towne Mfg. Co., 200 Henry St., and 48 Hillcrest Ave., Stamford, Conn.

BLACKMORE, Frederick H., (1923), Plant Mgr., U. S. Radiator Corp., and (for mail), 526 E. Vandalia St., Edwardsville, Ill.

BLACKMORE, George C., (Charter Member), 435 Maple Ave., Edgewood Park, Allegheny Co., Pa.

BLACKMORE, J. J.,* (Charter Member), Council 1896; Bd. of Gov. 1904; Secy. 1914-15), 32 West 40th St., New York, N. Y.

BLADON, James B., (1909), Chief Engr., Darling Bros., Ltd., 120 Prince St., Montreal, and (for mail), 33 Holton Ave., Westmount, Que., Can.

BLAIR, Wm. B., (Associate 1923), Taplin Furnace Co., 3006 First Ave., S., Minneapolis, Minn.

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.

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), Asst. to Pres., Richmond Radiator Co., and (for mail), White Swan Hotel, Uniontown, Pa.

BLODGETT, Will H., (Junior 1923), Htg. Engr., (for mail), Timken-Detroit Co., 4461 Cass Ave., and 691 Merrick, Detroit, Mich.

BLOMFELDT, Allen A., (1914), Sales Mgr., (for mail), 1lg Elec. Vtg. Co., 405 Union Central Bldg., Cincinnati, O., and 100 Mayo Ave., Newport, Ky.

BLOMQUIST, Edwin G., (Junior 1926), Salesman, U. S. Radiator Corp., 136 Federal St., Boston, and (for mail), 48 Alpine St., Arlington, Mass.

BLOOM, Samuel C., (1915), Sole Owner, (for mail), S. C. Bloom & Co., 53 W. Jackson St., and 1953 East 72nd St., Chicago, Ill.

BLOOM, William, (1924), Htg. Engr., (for mail), Bloom Htg. Systems, 153 Centre St., New York, and 701 Ave., C., Brooklyn, N. Y.

BOALES, William G., (Associate 1923), Salesman, Hoffman Specialty Co., 25 West 45th St., New York, N. Y., and (for mail), Webster Hall, Detroit, Mich.

BOARDMAN, Wallace E., (1923), Htg. and Vtg. Engr., (for mail), Stone & Webster, Inc., 147 Milk St., Boston, and 54 Pleasant St., Wakefield, Mass.

BOEKER, Carl Herman, (1926), Vice-Pres. and Gen. Mgr., 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 5243 N. Tenth St., Philadelphia, Pa.

BOISCLAIR, Hugh Cappes, (1926), Dist. Repr., (for mail), Warren Webster & Co., 342-3 Brown Marx Bldg., and 127 Pine St., Birmingham, Ala.

BOLLING, J. E.,* (Junior 1918; 1921), Publicity Engr., 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), D. D. Kimball, 15 West 38th St., New York, and (for mail), 1154 52nd St., Brooklyn, N. Y.

BOON, George, (1915), Vice-Pres. and Gen. Mgr., (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., and 4934 Baudinot St., Philadelphia, Pa.

BOSCHKE, F. G., (1925), 760 Kerckhoff Bldg., and 1111 West 51st St., Los Angeles, Calif.

BOSTAIN, James C., (1923), Sales and Service Engr., (for mail), Williamson Heater Co., 337 W. Fifth St., Cincinnati, and 3910 Floral Ave., Norwood, O.

BOSTWICK, Clinton G., (1924), Supt., (for mail), Braman Dow & Co., 239 Causeway St., Boston, and 20 Wedgemen Ave., Winchester, Mass.

BOSWIN, George A., (1917), Secy., (for mail), R. B. Haywood Co., 1714 Sheffield Ave., and 902 Diversey Parkway, Chicago, Ill.

BOWDEN, Frank, (Associate 1924), Chief Engr. and Instructor., (for mail), Windsor & Walkerville Tech. School. Giles Blvd., and 1609 Dougall Ave., Windsor, Ont., Can.

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.

BOWMAN, Howard A., (Associate 1926), Sales Engr., (for mail), American Radiator Co., 339 Second Ave., and 5599 Baum Blvd., Pittsburgh, Pa.

BOYD, D. Knickerbacker,* (1921), (for mail), Otis Bldg., 112 South 16th St., and Coronado Apts., 22nd and Chestnut Sts., Philadelphia, Pa.

BOYD, William R., (Junior 1924; Associate 1926), (for mail), Turner Supply Co., 8 W. Sixth St., and 702 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.

BRABBEE, Chas. W.,* (1925), (for mail), American Radiator Co., 675 Bronx River Rd., Yonkers, and DeWitt and Marguard Aves., Bronxville, N. Y.

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., Grand Rapids, Mich.

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.

BRADY, James L., (Associate 1925), (for mail), J. L. Brady Co., 551 15th Ave., and 1912 Third St., E. Moline, Ill.

BRAEMER, William G. R., (1915), Vice-Pres., (for mail), Universal Humidifying Co., 2013 Sansom St., Philadelphia, Pa., and 213 Warwick Rd., Haddonfield, N. J.

BRANDELES, H. J., (1921), Pres. and Mgr., (for mail), H. J. Brandeles Corp., 435 Lafayette St., and 66 Prospect St., Utica, N. Y.

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., The Schley & Nash Co., 709 Columbia Bk. Bldg., Pittsburgh, Pa.

BRAUN, Louis T., (1921), Secy., Chicago Master Steam Fitters Assn., 1213 Chamber of Commerce, and (for mail), 1418 Jonquil Terrace, Chicago, Ill.

BRAY, Daniel S., (Associate 1920), Local Mgr., (for mail), Peerless Heater Co., 1235-45 St. Clair Ave., and 9925 Olivet Ave., Cleveland, O.

BRECKENRIDGE, L. P., (1920), Prof. Mech. Engrg. (Emeritus), Sheffield Scientific School, Yale Univ., New Haven, Conn., and (for mail), "The Brackens," N. Ferrisburg, Vt.

BREDESON, C. R., (Junior 1921; Associate 1925), American Radiator Co. Prior Ave., and Minnehaha St., St. Paul, Minn.

BREEN, Jos. W., (1916), Htg. Engr., Wyalusing Ave. and Fallon St., and (for mail), 957 Fallon St., W. Philadelphia, Pa.

BREITENBACH, Walter J., (Junior 1923; Associate 1925), Designer and Estimator, Langenberg Mfg. Co., 4519-33 N. Euclid Ave., and 5067 Arlington Ave., St. Louis, Mo.

BRENDER, Peter E., (1920), Chief Engr., Univ. of Mich. Hospital, and (for mail), 13272 Geddes Ave., Ann Arbor, Mich.

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), Consulting Dry Kiln Engr., (for mail), 104 Baltimore Bldg., and 349 Hawthorne St., Memphis, Tenn.

BRICKEY, Joel P., (Associate 1924), 665 S. Pearl St., Denver, Colo.

BRIDE, W. T., (Junior 1925), Estimating Engr. and Draftsman, Bride, Grimes & Co., 526 Essex St., and 116 E. Haverhill St., Lawrence, Mass.

BRIDGES, Frank G., (1919), 433 Dundee Drive, Cleveland, O.

BRINTON, Joseph W., (1920), Mgr. Boston Office, (for mail), American Blower Co., 10 High St., Boston, and 9 Summit Ave., Brookline, Mass.

BRODERICK, Joseph F., (Junior 1914; 1918), Engr., Thompson-Starrett Co., 245 Hunters Point Ave., Long Island City, N. Y., and (for mail), P. O. Box 388, Springdale, Conn.

BROGAN, James J., (Associate 1917), Brogan & Co., (for mail), 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.

BROWN, Aubrey I., (1923), Ohio State Univ., Columbus, O.

BROWN, Edward R., (1920), (for mail), The Brown Co., 1053 Baltimore Ave., W., and 2290 LaMothe Ave., Detroit, Mich.

BROWN, Foskett,• (1926), Pres., (for mail), Foskett Brown Mfg. Co., 1608 Harrison St., P. O. Box 722, and Vanderbilt Campus, Nashville, Tenn.

BROWN, John H., (1920), Mgr., (for mail), Keasbey & Mattison Co., 429 N. Washington Ave., and 3704 Blaisdell St., Minneapolis, Minn.

BROWN, Robert H., (1926), Research Engr., (for mail), Parks-Cramer Co., 1102 Old South Bldg., Boston, and 75 Glen Rd., Jamaica Plain, Mass.

BROWN, Stephen J., (Associate 1919), Pres., Globe Vtg. Co., 205 River St., Troy, N. Y.

BROWN, William H., (Associate 1923), Mgr. Plbg. and Htg. Dept., C. E. Armstrong & Sons, 238 Fifth Ave., and 710 Seventh Ave., Clinton, Iowa.

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.

BRUEGGEMAN, Arthur R., (1920), Pres., (for mail), The A. R. Brueggeman Co., Keith Bldg., Cleveland, and 17220 Aldersyde Drive, Shaker Heights, 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., 320 West 48th St., and 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.

BRUSMAN, Harry M., (1923), Htg. and Sanitary Engr., Natl. Cash Register Co., Dayton, O.

BRYANT, Alice G.,* (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., 415 Spitzer Bldg., and 2907 Rockwood Place, Toledo, O.

BUCKLEY, Roy B., (Associate 1924), (for mail), The American Cornice Works Co., 237-41 N. Water St., and 161 S. Belmont Ave., Wichita, Kans.

BUDER, Chas. G.,* (1919), Western Sales Mgr., (for mail), Monarch Metal Products Co., 5020 Penrose St., and 1441 Hamilton Ave., St. Louis, 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, Arch., 715 Capital Bk. Bldg., and (for mail), 1666 Stanford Ave., St. Paul, Minn.

BUENSOD, Alfred C., (1918), Mech. Sales Engr., (for mail), Carrier Engrg. Corp., 39 Cortlandt St., and 125 West 12th St., New York, N. Y.

BULKELEY, Claude A.,* (1923), Supt. and Mech. Research Engr., (for mail), E. T. du Pont de Nemours & Co., du Pont Bldg., and 1313 W. Eighth St., Wilmington, Del.

BUMSTEAD, Francis Edwin, (1925), Owner, (for mail), Bumstead Htg. & Plbg. Co., 414 E. Dale St., and 803 N. Wohsatch Ave., Colorado Springs, Colo.

BUNNELL, Ercell W., (Junior 1923; 1924), Sales Engr., (for mail), Warren, Knight & Davis, Empire Bldg., and 812 Cotton Ave., Birmingham, Ala.

BURGER, John C., (1919), Estimator and Supt., (for mail), Geo. A. Henrich Co., 702 N. Wells St., and 7201 Chaplain Ave., Chicago, Ill.

BURKE, Fletcher H., (1925), Consulting Engr., (for mail), Fletcher H. Burke—John C. Wright, Associate, 681 Ellicott Sq., and 276 Sterling Ave., Buffalo, N. Y.

BURKE, George B., (1926), Vice-Pres., Sarco Co., Inc., 53 W. Jackson Blvd., Chicago, Ill.

BURNAP, Charles W., (1922), Herman Nelson Corp., 724 Commercial St., Emporia, Kans.

BURNETT, Earle S., (1920), Mech. Engr., (for mail), Bureau of Mines, U. S. Helium Prod. Plant, P. O. Box 602, and 4005 Oakland 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., 1728 Farwell Ave., Chicago, Ill.
BURR, Ralph J., (Associate 1919), Htg. Contracting, Standish, Mich.
BURRITT, Charles G., (Associate 1916), Mgr., (for mail), Johnson Service Co., 922 Second Ave., and 1425 LaSalle Ave., Minneapolis, Minn.
BURT, Henry Jackson, (Associate 1926), Consulting Engr., (for mail), 645 N. Michigan Ave., Chicago, and 416 Ellis Ave., Wheaton, Ill.
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., Century Bldg., Pittsburgh, and 94 Pilgrim Rd., Rosslyn Farms, Carnegie, Pa.
BUTLER, Peter D., (1922), Salesman, U. S. Radiator Corp., 101 Park Ave., New York, N. Y., and (for mail), 1131 Summit Ave., Jersey City, N. J.
BUTLER, Thomas F., (Associate 1919), Htg. Vtg. and Plbg., (for mail), 545 Broadway, and W. Erie and Madison Aves., Lorain, O.
BYRNES, Thomas F., (Junior 1924; Associate 1925), Htg. and Vtg. Engr., 53 Grove St., and (for mail), 58 Adelaide St., Hartford, Conn.
BYSOM, Leslie L., (1915), Public Works Dept., Puget Sound Navy Yard, and (for mail), 618 Boston St., Bremerton, Wash.

C

CADMUS, Raymond, (1922), Engr. and Estimator, Johnston Heat Co., 131 East 26th St., New York, N. Y., and (for mail), 11 Park Ave., Maplewood, N. J.
CADWELL, William H., (1916), Pres., (for mail), The Beaton & Cadwell Mfg. Co., P. O. Box 1012, and 130 W. Main St., New Britain, Conn.
CADZOW, William S., (1925), Mgr., V. N. Welamb Co., 2313 Walnut St., and (for mail), 1812 W. Tiogo St., Philadelphia, Pa.
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., Skillman Ave., and Hulst St., Long Island City, N. Y.
CALLAHAN, Thomas H., (Junior 1924), Pres., (for mail), Callahan Engrg., Co., Inc., 20 Grove St., and 248 S. Lexington Ave., White Plains, N. Y.
CALVERT, Norman W.,* (1921), Engr. of Steam Distribution, (for mail), The Detroit Edison Co., 2000 Second Ave., and 3297 Clements, Detroit, Mich.
CAMPBELL, Everett K.,* (1920), Pres. and Treas., (for mail), E. K. Campbell Htg. Co., 2445 Charlotte St., and 3717 Harrison Blvd., Kansas City, Mo.
CANTWELL, William T., (1920), Plbg. and Htg. Contracting, (for mail), 306 Bleecker St., and 1302 Brinckerhoff Ave., Utica, N. Y.
CARDER, William W., (Associate 1923), Br. Mgr., (for mail), *Johnson Service Co., 210 Bona* Allen Bldg., and 249 Peoples St., Atlanta, Ga.
CARLE, William E., (1926), Pres., (for mail), Carle-Boehling Co., 1641 W. Broad St., and 2220 Floyd Ave., Richmond, Va.
CARNAHAN, Glen C., (1924), Mgr., (for mail), Htg. Section, Peoples Gas, Light & Coke Co., 122 S. Michigan Ave., and 5428 Woodlawn Ave., Chicago, Ill.
CARPENTER, Randolph H., (1921), Mgr., New York Office, (for mail), Nash Engr. Co., 350 Madison 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.
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. and Mgr., (for mail), Majestic Furnace & Mfg. Co., Inc., 1723 Westlake Ave., N., and 102 W. Canal St., Seattle, Wash.
CARSTENS, Emil, (Junior 1922; Associate 1925), B. B. Smith Co., 49th and Grays Ave., and 4615 N. Rosehill St., Philadelphia, Pa.
CARTLAND, Silas, (Junior 1923), Sales Engr., (for mail), Juno Heater Corp., 30 N. Dearborn St., Chicago, and P. O. Box 84, Pentwater, Mich.
CARTY, Thomas, (1924), Pres., Carty Htg. Corp., 29 Audubon Ave., and 635 West 174th St., New York, N. Y.
CARY, Albert A.,* (Charter Member), (Bd. of Mgrs. 1894-1899; Council 1896), Consulting Engr., 95 Liberty St., New York, N. Y.
CASE, Edward W., (Associate 1916), Chrm. of Bd., W. A. Case & Son Mfg. Co., 220 Delaware Ave., Buffalo, N. Y.
CASEY, Byron L., (1921), Sales Engr., (for mail), Ilg Elec. Vtg. Co., 324 W. Monroe St., Chicago, and *501 Clifton Ave.*, Park Ridge, Ill.
CASH, Tidie T., (Associate 1925), Pres., (for mail), Cash Co., 240 Seventh Ave., S., and 20 Groveland St., Minneapolis, Minn.
CASSELL, John D.,* (1913), Supt. of Bldgs., (for mail), Board of Public Education, Keystone School Bldg., 19th and Chestnut Sts., Philadelphia, and 740 Garfield Ave., Palmyra, N. J.
CASSERLY, T. D., (Associate 1923), (for mail), Weil-McLain Co., 641 Lake St., W., and 5339 *Winthrop Ave., Chicago, Ill.*
CAVILEER, James V., (Associate 1921), Sales Engr., (for mail), Lewis, Robinson & Gant, 1302 Land Title Bldg., and 2938 North 27th St., 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., (for mail), 207 Franklin St., and 2803 Eserilh St., Tampa, Fla.
CHAPMAN, Frank T., (1909), (Board of Governors 1913; Council 1914-1916; 2nd Vice-Pres. *1915*; 1st Vice-Pres. 1916), Mgr. of Sales, 30 The Crescent, Montclair, N. J.
CHAPPELL, Temple Archer, (1926), Pres. and Gen. Mgr., (for mail), Weldon Sheet Metal Works, Inc., and P. O. Box 143, Weldon, N. C.
CHASE, John M., (Associate 1916), Vice-Pres. and Eastern Repr., (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 256 Keystone Ave., River Forest, Ill.
CHERRY, Lester A., (1921), Industrial Planning Corp., (for mail), 1102 Walbridge Bldg., and 155 Euclid Ave., Hertel Sta., Buffalo, N. Y.
CHERVEN, Victor W., (Associate 1920), Htg. and Vtg. Engr., (for mail), Holland Furnace Co., and 326 Maple Ave., Holland, Mich.
CHESTER, Thomas,* (1917), Consulting Engr., 718 B. Copeland St., Pittsburgh, Pa.
CHEYNEY, Charles C., (Junior 1913; Associate 1925), (for mail), Buffalo Forge Co., 562 W. Washington Blvd., Chicago, and Glencoe, Ill.
CHILDRESS, Worthie Lee, (1925), Partner, E. G. Harris & Co., 3312 W. Cary St., and 609 West 27th St. Richmond, Va.
CHITTENDEN, F. J., (Associate 1925), Mgr., (for mail), Walworth Co., Inc., 43 Carolina St., Buffalo, and 151 Pierce Ave., Hamburg, N. Y.
CHOFFIN, C. C., (1919), Secy. and Treas., W. J. Scholl & Co., Mahoning Ave. and Hogue St., Youngstown, O.
CHRISTIAN, Charles W., (1913), Htg. and Vtg. Engr. and Contractor., (for mail), Johnston Bldg., P. O. Box 292, and Myers Park, Charlotte, N. C.
CHUBB, John E., (Associate 1917), Gen. Mgr., Kelvinator Chicago, Inc., 209 N. Michigan Ave., Chicago, and (for mail), 806 Colfax St., Evanston, Ill.
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 439 Melrose St., Chicago, Ill.
CLARK, E. H., (1922), Br. Mgr., J. D. Swartwout Co., 482 Penobscot Bldg., and (for mail), Apt. 26, 132 Pingree St., Detroit, Mich.
CLARK, Fred C., (1923), Pres., F. C. Clark Htg. Co., 5941 Baum Bldv., and 505 N. Sheridan Ave., Pittsburgh, Pa.
CLARK, Homer J., (1919), Dist. Mgr., (for mail), Bayley Mfg. Co., 523 Penton Bldg., and 1372 Phelps Ave., Cleveland, O.
CLARK, W. Chas. M., (1915), Consulting Engr., (for mail), 130 Engrs. Bldg., and 2165 Cottage Grove Drive, Cleveland, O.
CLARK, William D., (1908), Htg. and Vtg. Engr., Richardson & Boyton 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 1018 Woodbourne Ave., Pittsburgh, Pa.
CLARKE, Howard W., (Associate 1923), Htg. and Vtg. Engr., Jas. Spear Stove & Htg. Co., 1823 Market St., Philadelphia, and (for mail), 512 Yale Ave., Swarthmore, Pa.
CLARKE, Samuel S., (1909), Htg. and Vtg. Engr., (for mail), Imperial Radiator Co., and Canadian Sirocco Co., 605 Second St., W., Calgary, Alberta, 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., 251 Broadway, Owatonna, Minn.
CLEGG, Carl, (1922), Mgr., (for mail), American Blower Co., 310 Mutual Bldg., and 3433 Homes St., 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), Hoffman Specialty Co., 2450 Main St., Bridgeport, Conn.
CLIFTON, Wm. F., (1923), 313 Brook Ave., Toronto, Ont., Can.
CLOUD, Oscar E., (Associate 1924), Mgr., (for mail), Western Sheet Metal Works, 450 N. Main St., and 529 Madison Ave., Wichita, Kans.
CLOUGH, Leslie, (1922), Htg. and Vtg. Engr., 75 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.
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), Senior Partner, (for mail), *The R. T. Coe Companies*, 522 Cutler Bldg., and 235 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., 207 Phoenix Bldg., Superior Ave., and East 17th St., Cleveland, and 1755 Northfield Ave., E. Cleveland, O.
COLE, Grant E., (Associate 1925), Mgr., (for mail), The Trane Co., 21-23 River St., and 75 Galley Ave., 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.
COLLIER, William I., (1921), Consulting Engr., (for mail), W. I. Collier & Co., 15 E. Fayette St., Baltimore, and Ellicott City, Md.
COMSTOCK, Glen Moore, (Associate 1926), Engr., (for mail), Rush Mchy. Co., 932 Oliver Bldg., Pittsburgh, and 154 College Ave., Beaver, Pa.
CONES, Benjamin, (1911), Secy. and Treas., Natl. Engrg. Co., (for mail), 2607 E. Washington St., and 420 N. Keystone Ave., Indianapolis, Ind.
CONNELL, Richard F., (1916), Mgr., (for mail), Capitol Testing Lab., U. S. Radiator Corp., 127 Campbell Ave., and 2970 Burlingame, Detroit, Mich.
CONNOLLY, Charles I., (Associate 1925), Sales Repr., Hoffman Specialty Co., Waterbury, Conn., and (for mail), 1716 Floyd Ave., Richmond, Va.
COOGAN, Jesse, (1915), Chief Engr., (for mail), Jesse Coogan Engrg. Co., 404-408 Boston Bldg., and Commercial Club, Salt Lake City, Utah.
COOK, Benjamin F., (1920), Member of Firm, Cook & White, 308 Mutual Bldg., Kansas City, and (for mail), Route 6, P. O. Box 452, Independence, Mo.
COOK, Chester D., (1921), Co-partner, (for mail), D. F. Edwards Htg. Co., 2340 Pine St., and 4264 Botanical Ave., 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.
COOLEY, Maxwell S.,* (1911), Bureau of Yards and Docks, Navy Dept., Washington, D. C., and (for mail), 5 E. Irving St., Chevy Chase, Md.
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., 515 Chemical Bldg., and 4305 Lindell Blvd., St. Louis, Mo.
COOPER, Thos. R., (1923), Shanghai Water Works Co., Shanghai, China.
COOPER, Thomas W., (Associate 1922), Mgr., (for mail), Utica Heater Co., 629 Chestnut 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.
CORNWELL, F. E., (Associate 1923), Salesman, (for mail), Natl. Htg. & Vtg. Co., Wausau, and 1463 Murray Ave., Milwaukee, Wis.
COSGROVE, Wallace M., (1923), Mgr., (for mail), American Radiator Co., 40 West 40th St., New York, N. Y., and 240 Ridgewood Rd., S. Orange, N. J.
COUGHLIN, R. J., (1925), Dist. Mgr., B. F. Sturtevant Co., 2086 Railway Exch., and (for mail), 4943 Spalding Ave., St. Louis, Mo.
COUSENS, Walter S., (1924), Treas., McLean & Cousens Co., 65 Chandler St., Boston, and (for mail), 70 Elm St., W. 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), Consulting Engr., (for mail), Warren Webster & Co., 326 Columbia St., and 5416 Kirkwood Place, Seattle, Wash.
CRANNELL, Chas. A., (1922), Secy., (for mail), Inland Engrg. Corp., 365 State St., and 1011 Park Place, Hammond, Ind.
CRAWFORD, William B., (1921), Mgr., Specialty Dept., (for mail), J. P. Marsh & Co., 114-124 S. Clinton St., and 1516 N. Mayfield Ave., 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), Directing Engr., Terrell Croft Engrg. Co., and Hotel Colon, Merida, Yucatan, Mexico.
CRONE, Charles E., Jr., (1922), Secy. and Treas., (for mail), Wendt & Crone Co., 1131 N. Wells St., and 5432 Woodlawn Ave., Chicago, Ill.
CRONE, Thomas E., (1920), Dist. Sales Mgr., W. A. Russell & Co., 5037 Grand Central Terminal Bldg., New York, N. Y., and (for mail), 50 Washington Terrace, E. Orange, N. J.
CROSBY, C. F., (1924), 27 William St., W. Somerville, Mass.
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.
CULLEN, Harry J., (1923), Htg. and Vtg. Engr., Warren & Wetmore, 16 West 47th St., New York, and (for mail), 15 Scott Place, Jamaica, N. Y.
CULLYFORD, Francis S., (1915), Pres. and Mgr., (for mail), Cullyford Plbg. & Htg. Co., 1210 California St., and 517 Josephine St., Denver, Colo.
CUMMINGS, Carl K., (Junior 1926), Mgr., Industrial Appliance Co. of N. E., 126 High St., Boston, Mass.
CUMMINGS, G. J., (1923), Supt., Scott Co., 113 Tenth St., and 201 Orange St., Oakland, Calif.
CUMMINS, George H., (1919), Sales Engr., (for mail), Morgan-Gerrish Co., 800-806 LaSalle Ave., and 4944 Logan Ave., S., Minneapolis, Minn.
CURRIER, Charles H., (1919), Vice-Pres., (for mail), Drying Systems, Inc., 50 Church St., and 322 West 72nd St., New York, N. Y.
CUTHBERT, Ivan Norman, (1925), (for mail), Cuthbert & Cuthbert, 327 E. Huron St., and Rural Route Number 6, Ann Arbor, Mich.
CUTLER, Joseph A., (1916), (Council 1917-1926), Mgr., (for mail), Johnson Service Co., 1355 Washington and Belden-Stratford Hotel, Chicago, Ill.
CUTTER, Edward H., (Associate 1923), Special Distributor, Hoffman Steam Specialties, (for mail), 179 W. Washington St., Chicago, and Elgin, Ill.
CUYLER, David H., (1917), Chicago Mgr., Natl. Radiator Co., 1038-1106 S. Kolmar Ave., Chicago, and 536 Hinman Ave., Evanston, Ill.

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DALY, John H., (1915), Pres. and Mgr., (for mail), Daly Co., 1425 16th 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), Mgr., Boston Office, The Trane Co., 15 School St., Boston, and (for mail), 9 Mason St., Medford, Mass.
DANFORTH, Newman Loring, (1919), Pres., John W. Danforth Co., 72 Ellicott St., Buffalo, N. Y.
DANNIES, F. R., (Associate 1925), Salesman, American Radiator Co., 1801 St. Paul Ave., and 465 Fourth Ave., Wauwatosa, 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.
DAUBACH, Charles T., (Associate 1925), Denver Mgr., (for mail), American Radiator Co., 24th and Blake Sts., and 237 Logan St., Denver, Colo.
DAUCH, Emil O., (1921), Detroit Repr., Continental Heater Corp., 400 Penobscott Bldg., Bldrs. and Traders Exch., and (for mail), 81 Montana Ave., W., Detroit, Mich.
DAUGHERTY, Fred M., (1919), Contracting Engr., Grinnell Co., Inc., 407 Society for Savings Bldg., Cleveland, O.
DAVENPORT, Edwin A., (1916), Htg. and Vtg. Engr., American Warming & Vtg. Co., 317-319 Pennsylvania Ave., Elmira, N. Y.
DAVIDSON, H. MacD., (Junior 1924; Associate 1926), Br. Mgr., (for mail), C. A. Dunham Co., 1820 St. Marys Ave., and 2118 Locust St., Omaha, Nebr.
DAVIDSON, Philip L., (1921; 1924), Sales Engr., Carrier Engrg. Corp., 176 Federal St., Boston, Mass.
DAVIES, George W., (1918), Htg. and Vtg. Engr., G. W. Davies & Co., 79 McLaggan St., Dunedin, New Zealand.
DAVIS, Arthur C., (1920), Mech. Engr., 73 Preston St., Ridgefield Park, N. J.
DAVIS, Benjamin H., (1923), 30 W. Lynwood Ave., Glenside, Pa.
DAVIS, Bert C., (1904), Pres. and Treas., (for mail), American Warming & Vtg. Co., 317 Pennsylvania Ave., and 603 W. Church St., Elmira, N. Y.
DAVIS, Jas. H., (Charter Member), (Board of Governors 1911), 816 S. Michigan Ave., Chicago, Ill.
DAVIS, Joseph, (Associate 1926), Htg. Engr., W. E. Shaddock, 2950 Oak St., and (for mail), 414 Northumberland Ave., Buffalo, N. Y.
DAVIS, Leo J., (1917), Vice-Pres., (for mail), John J. Davis & Sons, Inc., 2728 Baker St., Detroit, and Philbrick Ave., Reford, Mich.

HOBEN, Robert J., (1919), Plbg. and Htg. Contractor, (for mail), 258-60 S. Van Pelt St., and 5112 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), Hoersting & Holtmann, 1133 W. Third St., 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), Hoffman Specialty Co., 512 Fifth Ave., New York, N. Y.
HOFFMAN, James D.,* (1903), (Presidential Member), (Pres. 1910; 1st Vice-Pres. 1908; 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., 6004 Russell St., and 2970 W. Grand Blvd., Detroit, Mich.
HOGUE, Carl T., (1922), Htg. and Vtg. Engr., San Angelo, Tex.
HOIER, William V., (1917), Mgr., (for mail), Wm. V. Hoier Co., 701 N. Wells St., and 5960 Kenmore Ave., Chicago, Ill.
HOISINGTON, Ned P., (Associate 1923), 102 Summit Ave., Bywood Heights, Upper Darby P. O., Pa.
HOLBROOK, Frank M., (1923), Armstrong Cork Co., Linoleum Div., Lancaster, Pa.
HOLLOWAY, Robert B., (Junior 1923; Associate 1926), Gurney Heater & Mfg. Co., (for mail), 108 North 17th St., Philadelphia, and 26 W. Rockland St., Germantown, Pa.
HOLMBERG, John A., (1924), 122 E. Lincoln, Lindsborg, Kans.
HOLMES, Joseph, (1921), Htg. Engr., 1902 Freeman St., Toledo, O.
HOMANN, Frederick A., (1918), Sales Repr., The Herman Nelson Corp., 1233 Marlyn Rd., Philadelphia, Pa.
HONIBALL, Charles R.,* (1911), Pres., Charles R. Honiball Co., 156 Boundary St., Liverpool, Eng.
HOOK, C. Howard, (1915), Pres., Peerless Heater Co., 5602 Baum 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.
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.
HOUPT, George A., (1916), Engr., S. Faith Co., Inc., Evans Ave. and Old 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.
HOWELL, Frank B., (1920), Institution of Thermal Research, (for mail), American Radiator Co., 1807 Elmwood Ave., and Westbrook Apts., N. at Delaware, Buffalo, N. Y.
HOWELL, Lloyd, (1915), Chief Engr., (for mail), American Foundry & Furnace Co., 915 E. Washington St., and 1203 E. Jefferson St., Bloomington, Ill.
HOYT, William B., (1919), Sales Mgr. and Secy., (for mail), 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, Allen M., (1922), Prop., Htg. and Vtg. Contractor, 311 Temple St., and (for mail), 232 N. Vendome St., Los Angeles, Calif.
HUBBARD, G. W., (1911), Mech. Engr., (for mail), Graham, Anderson, Probst & White, 1417 Railway Exch., Chicago, and 331 Bonnie Brae, River Forest, Ill.
HUBBARD, Nelson B., (1919), Consulting Engr., (for mail), Rm. 1005, 1346 Broadway, and 2985 Blaine Ave., Detroit, Mich.
HUBERT, Jack W., (1924), Vice-Pres., Barron Hubert Co., 126 West 64th 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 Terrace, Germantown, Pa.
HUCKER, Joseph H., (1921), Sales Engr., (for mail), Haynes Selling Co., Inc., 1711 Sansom St., Philadelphia, and 715 Stanbridge St., Norristown, Pa.
HUETHER, Charles G. L., (Junior 1923; 1924), Htg., Vtg., Air Conditioning, Power and Mech. Equipment, Atlantic Engrg. Co., 109 E. Pleasant St., and 3814 Kate Ave., Forest Park, Baltimore, Md.
HUGHES, Willard C., (1921), (for mail), Wicks-Hughes & Co., 224 Genesee St., and 16 Cottage Place, Utica, N. Y.
HULL, Bret R., (1910), Engr. and Contractor, 406 Poyntz Ave., Manhattan, Kans.
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.
HUNT, Phil M., (1922), Htg. and Vtg. Engr., Crane Co., 336 S. Michigan Ave., Chicago, Ill., and (for mail), Pennsylvania Hotel, Chestnut and 39th Sts., Philadelphia, Pa.
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., 36-42 West 47th St., New York, N. Y., and 101-34 133rd St., Richmond Hill, L. I.
HUNTER, Wallace S., (Associate 1924), Vice-Pres., (for mail), United Plumbers Supply Co., Inc., 441 Exterior St., and 254 East 202nd St., New York, N. Y.
HURLEY, Joseph C., (1915), Pres., (for mail), Petroleum Fuel Engine Co., 4028-32 Filbert St., and 21 South 61st St., Philadelphia, Pa.
HUSBAND, Edward Woods, (1922), Htg. Engr., Geo. Frederic Hall, Archt., 807 Union Trust Co., Bldg., and (for mail), 114 Corinth St., Providence, R. I.
HUTCHINSON, J. Edward, (1921), Engr., (for mail), Isaac Hathaway Francis, 1520 Locust St., and 5129 Newhall St., Philadelphia, Pa.

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 722 W. Washington St., Ann Arbor, Mich.
HUTZEL, Hugo F., (1918), (for mail), American Radiator Co., 1807 Elmwood Ave., Buffalo, 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), Asst. Treas., Fleck Marshall Co., Hazel & Water Sts., and (for mail), 517 S. Lime St., 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), Pres., Hynes & Cox Elec. Corp., 406 N. Pearl St., and 50 S. Mansing Blvd., Albany, N. Y.

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IDDLES, Alfred, (1921), Chief Power Engr., (for mail), Day & Zimmermann, Inc., 1600 Walnut St., Philadelphia, and 304 Conestoga Rd., Wayne, Pa.
IMPEY, Paul F., (Junior 1921; Associate 1925), Htg. Engr., John C. Moninger Co., 900 Blackhawk St., and (for mail), 3842 N. Mozart St., Chicago, Ill.
INGALLS, F. D. B., (1906), Br. Mgr., Htg. and Sales Engr., (for mail), C. A. Dunham Co., 136 Federal St., Boston, and 1 Hopkins St., Reading, Mass.
INGELS, Margaret M.,* (Junior 1918; 1923), Research Engr., (for mail), U. S. Bureau of Mines, and 238 N. Dithridge St., Pittsburgh, Pa.
INNIS, Helen R., (Junior 1918; 1921), Donnelly Systems Co., (for mail), 9 Murray St., New York, and 34 McDonough St., Brooklyn, N. Y.
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), 412 Clark Bldg., Jacksonville, and Jacksonville Beach, Fla.
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), Local Mgr., (for mail), Jenkins Bros., 646 W. Washington Blvd., Chicago, and 323 Hazel Ave., Glencoe, Ill.
JACKSON, Marshall S., (1919), Htg. and Power Plant Equipt., (for mail), 232 Delaware Ave., and 108 Larchmont Rd., Buffalo, N. Y.
JACKSON, Tandy L., (Junior 1926), Pres. and Gen. Mgr., (for mail), Tandy L. Jackson Co., Mutual Bldg., and 3524 Campbell St., Kansas City, Mo.
JACOBUS, Davis S., (1916), Advisory Engr., Babcock & Wilcox Co., 85 Liberty St., New York, N. Y.
JALIEN, John J., (1922), Staff Engr., (for mail), 552 Seventh Ave., and 365 West 118th St., New York, N. Y.
JANES, Arthur, (1919), Pres., Arthur Janes Co., 990 Post Rd., Scarsdale, 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), Plbg. and Htg. Contr., *Jardine & Knight* Plbg. & Htg. Co., 312 N. Custer, and 509 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), (for mail), 525 S. Seventh St., and 4849 Girard Ave., S. Minneapolis, Minn.
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), U. S. Cartridge Co., and 343 High St., Lowell, Mass.
JENNINGS, Irving C., (1924), Pres., (for mail), Nash Engrg. Co., and 138 Flax Hill Rd., S. Norwalk, Conn.
JENNINS, Henry H., (1901), Managing Director, E. Oldroyd & Co., Ltd., and (for mail), 15 Grange View, Leeds, Eng.
JENSON, Jean S., (1912), 431 S. Dearborn St., Chicago, Ill.
JOHN, Benjamin F., (1920), Pres., (for mail), Benjamin F. John Co., 1003 Race St., and 881 North 24th St., Philadelphia, Pa.
JOHNSON, Carl W., (1912), Pres., (for mail), C. W. Johnson, Inc., 211 N. Desplaines St., and 1809 Morse Ave., Chicago, 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 Terrace, and (for mail), 154 Wardwell Ave., W. New Brighton, N. Y.
JOHNSON, Fred W., (1916), Vice-Pres., (for mail), *Johnson, Larsen & Co.,* 693-703 Monroe Ave., Detroit, and R. F. D. No. 4, Birmingham, Mich.
JOHNSON, Paul H., (Associate 1924), Engr., E. H. Sheldon Co., and (for mail), 205 Washington Ave., Muskegon, Mich.
JOHNSON, Ralph B., (1922), Sales Engr., (for mail), Johnson Service Co., 411 E. Tenth St., and 2117 East 68th St., Kansas City, Mo.
JOHNSON, Tracy R., (1924), Mgr., Engr. Dept., The Trane Co., and 315 Y. M. C. A., LaCrosse, Wis.
JOHNSTON, James Ambler, (1912), Member of Firm, Carneal & Johnston, Architects and Engrs., 806 Electric Bldg., and 1411 Grove Ave., Richmond, Va.
JOHNSTON, R. E., (Associate 1926), Htg. Engr., Taylor Forbes Co., 1070 Homer St., Vancouver, B. C.
JOHNSTON, William B., (Associate 1916; 1921), Vice-Pres., (for mail), Ideal Furnace Co., 2995 E. Grand Blvd., and 1667 Atkinson Ave., 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, A. Marshall, (1922), Mgr., (for mail), Machinery Mfgs. Sec., Westinghouse Elec. & Mfg. Co., E. Pittsburgh, and 209 Biddle Ave., Wilkinsburg, Pa.
JONES, David J., (1919), Mech. Asst., (for mail), *Illinois Central Railroad Co.,* Rm. 700, Dowie Bldg., and 425 89th Place, Chicago, Ill.
JONES, Dwight C., (Associate 1924), (for mail), Hoffman Specialty Co., 200 Builders Exchange, and 4508 29th Ave., S., Minneapolis, Minn.
JONES, Earnest F., (1923), Mgr., Htg. Dept., (for mail), Kellogg-Mackay Co., 1351 West 37th Place, and 3350 Gladys Ave., Chicago, Ill.
JONES, Edwin, (Junior 1924), Watt Plbg., Htg. & Supply Co., Box 582, Tulsa, Okla.

JONES, Edwin A., (1919), Contracting Engr., L. J. Mueller Furnace Co., 197 Reed St., Milwaukee, Wis.
JONES, Edwin F., (1923), Consulting Engr., 301 Zenith Bldg., St. Paul, Minn.
JONES, Ernest, (Associate 1925), 423 Dwight Bldg., Kansas City, Mo.
JONES, Harold L., (1920), Asst. Supt., The W. W. Farrier Co., (for mail), 44 Montgomery St., Jersey City, and 11 Cambridge Rd., Glen Ridge, N. J.
JONES, Ivor R., (Junior 1923), (for mail), Isaac H. Francis, 1520 Locust St., Philadelphia, and 344 Taylor Terrace, Chester, Pa.
JONES, Louis T., (1921), Salesman, 3700 Highland Ave., Drexel Hill, Delaware Co., Pa.
JONES, Raymond E., (1919), Pres., (for mail), Haynes Selling Co., Inc., 2013 Sansom St., Philadelphia, Pa., and 39 W. End Ave., Haddonfield, N. J.
JONES, William T., (1915), (Council 1925-1926), Partner, Barnes & Jones, 5 Melrose St., Boston, 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 Corp. of America, 342 Madison Ave., New York, N. Y., and Dessau, Germany.
JUTTNER, Otto J., (1915), Pres., (for mail), Juttner Heating Co., 43 Jefferson St., Milwaukee, and 496 Newton Ave., Shorewood, Wis.

K

KAHN, Henry P., (1919), Salesman, Hoffman Specialty Co., 512 Fifth Ave., and (for mail), 456 West 148th St., New York, N. Y.
KAISER, Harry S., (Junior 1924), Htg. and Vtg. Engr., Hanley & Co., 6 N. Clark St., and (for mail), 3608 Wilson Ave., Chicago, Ill.
KAMMAN, Arnold R., (Junior 1921; Associate 1925), Engr., John W. Danforth Co., 72 Ellicott St., and (for mail), 441 Massachusetts Ave., Buffalo, N. Y.
KAMMERER, William C., (1923), Mech. Engr., Hadlow, Hick & Co., 412 Finance Bldg., Cleveland, and (for mail), 14915 Clofton Blvd., Lakewood, O.
KAPPEL, George W. A., (1921), Pres. and Treas., (for mail), Camden Heating Co., 8 Market St., Camden, and 347 King's Highway W., Haddonfield, N. J.
KARLSON, Alfred F., (1918), Chief Engr., (for mail), Parks-Cramer Co., 970 Main St., Fitchburg, and 186 Prospect St., N. Leominster, Mass.
KARR, Theo., Jr., (1921), Karr Supply Co., (for mail), and 325 S. High St., Belleville, Ill.
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. and Contractor, (for mail), 4308 N. Broad St., and 326 W. Seymour St., Philadelphia, Pa.
KAUFFMANN, Frederick F., (1922), Consulting Engr., (for mail), 13 North 13th St., Philadelphia, Pa., and 909 Pine St., Camden, N. J.
KAYSING, Harry C., (1926), Designer and Engr., Hester-Bradley Co., 4200 Forest Park Blvd., St. Louis, Mo.
KEASBEY, Aertsen Parry, (1922), Vice-Pres., (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), Editor, Domestic Engineering, 1900 Prairie Ave., and 70th St., and The Lake, Chicago, Ill.
KEHM, August, (1901), (Board of Governors 1908; 1911; 1st Vice-Pres. 1909), Pres., Kehm Bros. Co., 51 E. Grand Ave., Chicago, Ill.
KEISER, Walter, (Associate 1920), Vice-Pres., (for mail), Keiser Equipment & Engrg. Co., 580 Arcade Bldg., and Wydom Blvd. and Bolland Drive, St. Louis, Mo.
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, Clarence V., (Associate 1900), Pres., (for mail), Kellogg-Mackay Co., 1357 West 37th Place, and 1338 Fargo Ave., Chicago, Ill.
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), Salesman, (for mail), The Bishop & Babcock Co., 444 Lafayette St., New York, and 23 Roxbury Rd., Scarsdale, N. Y.
KELLY, John G., (Associate 1919), Plbg. and Htg. Specialties, 210 East 45th St., New York, and (for mail), 55 Cornell Ave., Yonkers, N. Y.
KENT, Laurence F., (Junior 1924), Vice-Pres. and Engr., Moncrief Furnace Co., P. O. Box 1073 Atlanta, and R. F. D. No. 2, Smyrna, Ga.
KERNEY, Thomas F., (Junior 1925), Engr., (for mail), H. B. Hackett, Consulting Engr., Public Ledger Bldg., and 2115 W. Ontario 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., 11 S. Desplaines St., Chicago, Ill., and 2497 Grand Ave., New York, N. Y.
KIEB, August A., (1924), Engr., F. P. Merkel, 131 South 12th St., and (for mail), 112 S. Tenth St., Newark, N. J.
KIEFER, Carl J., (1922), Consulting Engr., 901 Schmidt Bldg., Cincinnati, O.
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., Northwestern Htg. & Plbg. Co., 1465 Sherman Ave., 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, Mass.
KIMBALL, Dwight D.,* (1908), (Presidential Member), (Pres. 1915; Board of Governors 1912; 1913; 2nd Vice-Pres. 1914; Council 1914-1916), 15 West 38th St., New York, and 230 23rd St., Jackson Heights, L. I., New York.
KINEALY, John H.,* (Charter Member; Presidential Member), (Pres. 1901; 1st Vice-Pres. 1898; Board of Governors 1902), Consulting Engr., 503 Granite Bldg., St. Louis, Mo.
KING, Thomson, (1923), Sales Mgr., (for mail), Gas Boiler Dept., Peerless Heater Co., 5602 Baum Blvd., and 209 N. Lang Ave., Pittsburgh, Pa.
KINGSBURY, James W., (1924), B. B. Shine, 224 E. Walnut St., Green Bay, Wis.
KINGSLEY, E. A., (1926), Pres., E. A. Kingsley & Co., Inc., 14 Gansevoort Ave., New York, N. Y.
KINNER, J. E., (1924), Bryant Heater & Mfg. Co., 952 East 72nd St., and 1453 East 116th St., Cleveland, O.

KIPE, J. Morgan, (1919), Philadelphia Mgr., (for mail), Standard Heater Co., 609 Otis Bldg., and Homestead and Beck Aves., Beechwood Park, Philadelphia, Pa.
KIRBY, W. C., (1918), Consulting Engr., (for mail), Grinnell Co., Inc., 276 Marrietta St., Atlanta, and 306 Ponce de Leon Place, Decatur, Ga.
KIRK, Charles D., (1909), Mgr., Chas. D. Kirk Co., Sargent and Colleen Sts., and 774 McMillan Ave., Winnipeg, Manitoba, Can.
KIRK, George H., (1906), Engr. and 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), Secy. and Chief Engr., (for mail), Walworth-English-Flett Co., 81 Commercial Wharf, Boston, and 29 Oakland St., Melrose, Mass.
KISSICK, J. J., (1918), Supt. of Operations, 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., (Junior 1923), John H. Kitchen Co., 1012 Pioneer Trust Bldg., 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 42 Main St., Irvington-on-Hudson, 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., (1920), Mgr., Carrier Luft-technische 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 227 Myrtle St., Atlanta, Ga.
KLEIN, Walter A., (1919), Pres., (for mail), Klein Htg. Co., 4209 Olive St., and 4061a Shaw Ave., St. Louis, Mo.
KLIE, Walter, (1915), Pres., (for mail), The Smith & Oby Co., 6107 Carnegie Ave., Cleveland, and 18411 S. Woodland Rd., Shaker Heights, Cleveland, O.
KLINE, George W., Jr., (1921), Proprietor, Kline & Co., 311 North 13th St., and (for mail), 634 North 17th St., Philadelphia, Pa.
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.
KNAPP, A. F., (1923), Sales Engr., 419 Post Ave., Lyndhurst, N. J.
KNIGHT, Alvin B., (Associate 1916), (for mail), Warren Webster & Co., 2123 Dime Bk. Bldg., and 8818 Dexter Blvd., 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., 804 Times Dispatch Bldg., Richmond, Va.
KOEHLER, George T., (1923), Br. Mgr., Richmond Radiator Co., 1480 Broadway, New York, N. Y., and (for mail, 1111 Market St., Harrisburg, Pa.
KOHLBRY, Edward G., (1920), Pres., (for mail), Kohlbry-Howlett Co., 63 W. Ontario St., Chicago, and 1144 Chestnut Ave., Wilmette, Ill.
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, Htg., Vtg., Roofing and Sheet Metal Contractors, 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), Htg. Estimator, Alvord & Swift, Grand Central Terminal, New York, and (for mail), 108 Linden St., Brooklyn, N. Y.
KRESSLY, Maurice E., (1922), Htg. and Vtg. Engr., Bureau of School Bldgs., Dept. of Public Instruction and (for mail), 1941 Lenox St., Harrisburg, Pa.
KRIEBEL, Arthur E., (1920), Service Engr., (for mail), Haynes Selling Co., 2013 Sansom St., Philadelphia, and Berwyn, Chester Co., Pa.
KRIES, Henry A., (1901), Pres., (for mail), Henry A. Kries & Sons Co., 6 W. Lombard St., Baltimore, and Catonsville, Md.
KROEGER, Alvin, (Associate 1923), Chicago Mgr., (for mail), Richmond Radiator Co., 568 Wrigley Bldg., and 4056 N. Harding Ave., Chicago, Ill.
KRUEGER, James I., (1921), Mech. Htg. and Vtg. Engr., (for mail), Illinois Engrg. Co., 417 Market St., Suite 320, and 1770 Pacific Ave., San Francisco, Calif.
KRUEGER, William E., (Associate 1924), Mgr. Htg. Dept., Passaic Plumbing Co., Passaic, and (for mail), 453 Devon St., Arlington, N. J.

L

LaFOLLETTE, Byron E., (1916), Vice-Pres. and Treas., The Tarpenning-LaFollette Co., (for mail), 1030 Canal St., and 3415 Guilford Ave., Indianapolis, Ind.
LAGODZINSKI, Harry J., (Junior 1920), Sales Engr., Ilg Elec. Vtg. Co., (for mail), 324 W. Monroe St., and 3628 N. Tripp Ave., Chicago, Ill.
LAIDLAW, Ernest J., (Associate 1923), (for mail), Crane Co., Ltd., 306 Front St., and 629 Lonsdale Rd., Toronto, Ont., Can.
LAMB, Foster W., (1906), Pres., F. W. Lamb Co., 24 E. Kinzie St., Chicago, and Oak Park Arms Hotel, Oak Park, Ill.
LAMSON, F. S., (1924), Mgr. Htg. and Pumping Dept., Central Supply Co., 312 S. Third St., and (for mail), 2319 Dupont Ave., S., Minneapolis, Minn.
LANCE, Joseph, (1923), Harrigan & Reid, 1705 First St., Detroit, Mich.
LANDERS, John J., (Junior 1924), Htg. Engr., (for mail), U. S. Radiator Corp., 133 E. Grand River, and 17004 Log Cabin Ave., Detroit, Mich.
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 1508 Larrabee St., 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., St. Louis, Mo., and 7214 Pershing Ave., University City, Mo.
LARIMER, G. B., (1915), Pres., Larimer & Lauer, (for mail), 1824 S. Hope St., and 6666 Selma Ave., Hollywood Sta., Los Angeles, Calif.

LARIMER, Wm. McCoy, (1922), Mgr. Htg. Dept., (for mail), Crane O'Fallon Co., 1621 15th St., 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, 504 Civic Block, and 11317 91st St., Edmonton, Alberta, Can.
LAU, Anton S., (1926), Mech. Engr., Cross & Cross, Archts., 385 Madison Ave., New York, N. Y., and 35 Woodland Rd., Bloomfield, N. J.
LAUTENSCHLAGER, Fred, (1915), Mgr. Greenhouse Dept., (for mail), Brunswick-Kroeschell Co., 4221 Diversey Ave., and 3846 Alta Vista Terrace, Chicago, Ill.
LAVAN, P. J., (1921), Htg. Contractor, (for mail), 1319 Eighth Ave., and 4232 Bagley Ave., Seattle, Wash.
LAWRENCE, Charles E., (1922), N. Y. Sales Mgr., (for mail), Massachusetts Blower Co., 444 Lafayette St., New York, and 52 Waldorf Circuit, Brooklyn, N. Y.
LeBEAU, John F., (1924), Cascade Automatic Sprinkler Corp., Grand Central Terminal, New York, and (for mail), 97-23 Whittier Ave., Jamaica, N. Y.
LeCOMPTE, William G., (Associate 1914), Sales Mgr., (for mail), Jenkins Bros., 80 White St., and 112 East 81st St., New York, N. Y.
LEEK, Walter, (1903), Leek & Co., 1090 Homer 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), Engr., (for mail), Fowler & Karges, 707 Furniture Bldg., and 900 Powell Ave., Evansville, Ind.
LEGIER, Edward W., (1924), Monarch Metal Products Co., 5020 Penrose St., St. Louis, Mo.
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., The Arthur S. Leitch Co., Ltd., (for mail), 1123 Bay St., and 421 Russell Hill Rd., Toronto, Can.
LELAND, William E., (1915), Consulting Engr., 58 Sutter St., San Francisco, Calif.
LENONE, Jose M., (1919), Engr., Armour & Co., General Office, U. S. Yards, and (for mail), 4808 Dorchester Ave., Chicago, Ill.
LEONHARD, Frederick, (1921), Sales Engr. and Mgr., Jas. P. Marsh & Co., 536 East 123rd St., Cleveland, O.
LEUSCH, Victor William, (Associate 1926), Htg. and Vtg. Engr., W. W. Sibley, 416 S. Fellows St., and (for mail), 1615 Medora St., South Bend, Ind.
LEVIN, Joseph, (Associate 1923), Power Equipment Co., 1015 Chestnut St., Philadelphia, Pa.
LEWIS, Edward B., (1924), Natl. Htg. and Vtg. Co., (for mail), 619 Washington Ave., S., Minneapolis, and 2283 Commonwealth Ave., St. Paul, Minn.
LEWIS, George C., (1919), Sales Engr., American Htg. & Vtg. Co., 1505 Race St., Philadelphia, Pa.
LEWIS, J. Clifford, (1913), Mech. Engr., (for mail), Lewis & Warren, 1001-3 Realty Bldg., 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. Contr., 7127 Grays Ave., and (for mail), 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), (Council 1923-1926), Pres. and Gen. Mgr., (for mail), York Htg. & Vtg. Corp., 1502 Locust St., Philadelphia, and 346 Calvert Rd., Merion, Pa.
LIBBY, Lawrence R., (1900), Pres. and Treas., (for mail), Libby & Blinn, Inc., 135 Sheldon St., and 629 New Britain Ave., Hartford, Conn.
LICHTY, Arthur J., (Junior 1923), Sales Engr., (for mail), C. A. Dunahm Co., 507 North 22nd St., and 1011 Tuscaloosa Ave., Birmingham, Ala.
LICHTY, Charles P., (1920), Engr., C. P. Lichty, 507-509 North 22nd St., and 1011 Tuscaloosa 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), Supt. and Mgr., (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., Roberts Ave., W. of Wayne Ave., Wayne Jct., Philadelphia, Pa. and Haddon Ave., W. 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.
LIPPE, Ernest V., (1922), Consulting Mech. Engr., Rm. 840, 332 S. La Salle St., Chicago, and (for mail), 5340 S. Kimbark Ave., Chicago, Ill.
LIPPMAN, Orville S., (Associate 1920), Sales Repr., (for mail), The Kellogg-Mackay Co., 1351 West 37th Place, and 7251 Princeton Ave., Chicago, Ill.
LITTLE, C. W., (1921), Dept. Mgr., (for mail), Grinnell Co., Inc., 413 Capitol Theatre Bldg., and 489 Eastlawn Ave., Detroit, Mich.
LITTLE, Edwin R., (1916), Consulting Engr., (for mail), E. R. Little Co., Inc., 1918-1920 Ford Bldg., and 1463 Lawrence Ave., Detroit, Mich.
LOCKE, Hiram W., (1920), Htg. Engr. and Sheet Metal Worker, 1942 North 20th St., Philadelphia, Pa.
LOCKER, Charles W., (1916), Mgr., (for mail), C. A. Dunham Co., Rm. 101, 2845 Grand River Ave., Detroit, and R. F. D., Farmington, Mich.
LOCKWOOD, Edwin H.,* (1915), Asst. Prof. Mech. Engrg., Sheffield Scientific School, Yale University, and (for mail), 51 Sheldon Terrace, 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.
LONDON, Irving, (Junior 1924), Engr. and Estimator, (for mail), Raisler Heating Co., 129 Amsterdam Ave., New York, and 1660 Union St., Brooklyn, N. Y.
LONGENECKER, Howard J., (1917), Pres. and Gen. Mgr., (for mail), York Htg. & Vtg. Co., 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), Brewster Rd., Hartsdale, N. Y.
LORD, Frank Russell, (1922), Mgr. Htg. Dept., (for mail), Walworth Mfg. Co., 245 Arch St., Philadelphia, Pa., and Delanco, N. J.
LOVE, Clarence H., (1919), Mfgr. Agent, (for mail), Nash Engineering Co., 840 Ellicott Sq., and 289 Norwalk Ave., Buffalo, N. Y.
LOVELACE, James A., (1920), Vice-Pres. and Gen. Supt., R. L. Spitzley Heating Co., 246 Larned St., W., Detroit, Mich.

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., Columbia University, and 260 Riverside Drive, New York, N. Y.
LUMSDEN, Edward R., (1923), Pres., (for mail), E. R. Lumsden Co., 728 Philadelphia St., and 737 Water St., Indiana, 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., Newark, and 1200 W. Seventh St., 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.

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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), Rm. 614, 131 Livingston St., and 1616 E. Tenth St., Brooklyn, N. Y.
McCARTHY, Bernard J., (1925), Mgr. Htg. Dept., The P. & H. Supply Co., 225 Columbus St., and 2306 Fairfield Ave., Ft. Wayne, Ind.
McCARTHY, Charles J., (1919), Contractor, (for mail), Chas. J. McCarthy, 808 Otis Bldg., and 533 South 55th St., Philadelphia, Pa.
McCARTHY, T., (1921), Htg. Contractor, (for mail), McCarthy & Crandall Plbg. & Htg. Co., 529 S. Cascade Ave., and 444 W. Yampa St., Colorado Springs, Colo.
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., 140 S. Dearborn St., and 833 Galt Ave., Chicago, Ill.
McCLINTOCK, Alexander, Sr., (1917), Pres., (for mail), A. McClintock & Son, 1937 Ridge Ave., Philadelphia, and 121 Rochelle Ave., Wissahickon, Philadelphia, Pa.
McCLINTOCK, Alexander, Jr., (Junior 1920), Htg. Engr., (for mail), 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.
McCLOSKEY, John, (1923), 458 48th St., Brooklyn, N. Y.
McCOLL, Jay R.,* (1916), (Presidential Member), (Pres. 1922; 2nd Vice-Pres. 1920; 1st Vice-Pres. 1921; Council 1923), Dean of Engrg., Univ. of Detroit, Consulting Engr., (for mail), McColl, Snyder & McLean, 2348 Penobscot Bldg., and 825 Chicago Blvd., Detroit, Mich.
McCORMICK, Edward T., (Associate 1923), Br. Mgr., Pierce, Butler & Pierce Mfg. Corp., 600 Second Ave., Pittsburgh, Pa.
McCOY, Thomas F., (1924), Mgr., (for mail), The Powers Regulator Co., 263 Summer 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.
McCREERY, Hugh J., (1922), Mgr., (for mail) Combustion Engrg. Corp., Ltd., Bank Bldg. and 1355 12th 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.
McDONALD, John C., (1920), Br. Mgr., (for mail), U. S. Radiator Corp., 1412 West 12th St., Kansas City, Mo.
McDONNELL, Everett N., (1923), Partner, (for mail), McDonnell & Miller, Wrigley Bldg., 400 N. Michigan Blvd., and 627 Arlington Place, Chicago, Ill.
McELLROY, George Sheffler, (1925), Engr., R. T. Withers Sons Co., 111 N. Shenango St., and (for mail), 407 Clenmore Blvd., New Castle, Pa.
McEVOY, William J., (1917), Mech. Engr., McFarland & Kitzelman Co., 520 West 36th St., Chicago, and (for mail), 1326 Columbia Ave., Rogers Park, Chicago, Ill.
McFARLAND, William P., (Associate 1923), Salesman, Powers Regulator Co., 2720 Greenview Ave., and (for mail), 1106 Columbia Ave., Chicago, Ill.
McGINNESS, J. E., (1903), Pres., (for mail), McGinness, Smith & McGinness Co., 527 First Ave., and 142 Bellefield 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.
McGOWAN, Thomas F., (1921), Htg. and Contracting Engr., 2832 Girard Ave., Philadelphia, Pa.
McGREGOR, George H., (1920), Mgr., (for mail), Western Htg. Co., 5051 W. Chicago Ave., Chicago, and 902 S. Cresent Ave., Park Ridge, Ill.
McGUIGAN, L. A., (Associate 1919), Salesman, Natl. Radiator Co., 215 Wood St., and (for mail), 724 Hastings St., Pittsburgh, Pa.
McHENRY, Robert W. M., (1921), Asst. Engr., M. F. Thomas, 229 College St., and (for mail), 236 Eglinton Ave., E., Toronto, Ont., Can.
McINTIRE, James F., (Associate 1914; 1915), (Council 1926), Vice-Pres., (for mail), U. S. Radiator Corp., 133 E. Grand River Ave., and 2061 Taylor Ave., 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.
McINTYRE, William N., (1917), Supt., A. Haltman Heating Co., 700 East 18th St., and (for mail), 6027 Cherry St., Kansas City, Mo.
McKENNA, William N., (1912), Treas., (for mail), Wm. N. McKenna Co., 79 Chestnut St., and 21 W. Cedar St., Boston, Mass.
McKENZIE, Paul C., (Associate 1925), Sales Engr., (for mail), Herr-Harris Co., 910 Fulton Bldg., Pittsburgh, and 2724 Connecticut Ave., Dormont, Pa.
McKIEVER, Wm. H.,* (Junior 1896; 1897), Consulting and Contracting Engr., (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.
McLEAN, Dermid, (1917), (for mail), McColl, Snyder & McLean, Consulting Engrs., 2348 Penobscot Bldg., and 5140 Ridgewood Ave., Detroit, Mich.
McLEAN, Ivory D., (1924), Pres., (for mail), McLean & Cousens Co., 65 Chandler St., Boston, and 156 Coolidge St., Brookline, Mass.
McLELLAND, H. Burton, (Associate 1912), Salesman, Jenkins Bros., 640 Washington Blvd., and 129 N. Menard Ave., Chicago, Ill.
McMAHON, W. W., (Associate 1923), Mgr., (for mail), Natl. Regulator Co., 166 Lexington Ave., and 2950 Bainbridge 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., New York, and Larchmont, 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), Draftsman, The McMurrer Co., 303 Congress St., Boston, and (for mail), 37 Walnut St., Everett, Mass.
McNAIR, Edward E., (1915), (Council 1921; 1922; 2nd Vice-Pres. 1923), Vice-Pres., (for mail), U. S. Radiator Corp., 133 E. Grand River Ave., Detroit, and Birmingham, Mich.
McVEHIL, Earl W., (1923), Mgr., McVehil Plbg. Co., 40 E. Wheeling St., Washington, Pa.

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MacDADE, Ambrose H., (1923), Haynes Selling Co., Inc., 1711 Sansom St., Philadelphia, Pa.
MacDOUGALL, Burgess W., (1923), Mech. Supt., State of New Jersey, State Office Bldg., Trenton, and (for mail), 219 Netherwood Ave., Plainfield, N. J.
MACFARLANE, J. Grant, (Associate 1925), P. O. Box 147, Cumberland, Md.
MACKENSEN, Wm. H., (1923), Estimator and Designer, (for mail), The Huffman-Wolfe Co., 669 N. High St., and 84 Brevoort Rd., Columbus, O.
MacKENZIE, Burt, (1924), Htg. and Vtg. Contractor, 349 N. Elm St., and P. O. Box 353, 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.
MACON, William W.,* (1908), (Secy. 1911; 1912; Board of Governors 1913; Council 1914), Editor, (for mail), Iron Age, 239 West 39th St., New York, and 711 Ave. J., Brooklyn, N. Y.
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.
MAHONEY, David John, (Associate 1926), Br. Mgr., (for mail), Johnson Service Co., 503 Franklin St., and 546 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), Designing Engr., New York Blower Co., 2246 S. Halsted St., and (for mail), 1044 West 70th St., Chicago, Ill.
MALLIS, William, (1914), Architect and Engr., (for mail), 326 Lyon Bldg., and North Gate Apts., First Ave., Seattle, Wash.
MALONE, Dayle G., (Associate 1925), Htg. Engr., Hardin-Lavin Co., 121-139 W. Pershing Rd., and (for mail), 5439 Kimbark Ave., Chicago, Ill.
MANAHAN, James E., (Junior 1926), Vice-Pres., Manahan Engrg. & Equipt. Co., 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., Beverly, N. J.
MANSELL, P. C., (1921), (for mail), Purdy-Mansell, Ltd., 63 Albert St., and 26 Grassmere Rd., Toronto, Ont., Can.
MANSFIELD, F. A., (Associate 1920), Dist. Mgr., (for mail), The Louis Allis Co., 1213 Bessemer Bldg., and 600 Shady Ave., Pittsburgh, Pa.
MAPPETT, Alfred S., (Charter Member), Treas., Fowler & Wolfe Mfg. Co., 621 Bulletin Bldg., Philadelphia, Pa.
MARCH, Ralph C., (1919), Htg. Engr., (for mail), Public Service Co. of North Illinois, 114 S. Oak Park Ave., Oak Park, and 376 Grove St., Lombard, Ill.
MARKEL, Frank E., (1923), Mech. Engr., (for mail), The Markel Co., Engrs., 1001-3 Wynns-Claughton Bldg., and 937 E. North Ave., Atlanta, Ga.
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., Univ. of Minnesota, and (for mail), 131 Orlin Ave., S.E., Minneapolis, Minn.
MARTIN, Albert B., (1917), Dist. Sales Mgr., (for mail), Kewanee Boiler Co., 822 W. Washington Blvd., Chicago, and 997 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, 66 Exchange St., and (for mail), 166 Glenwood Ave., Pawtucket, R. I.
MARTIN, O. Waldemar, (1925), Chicago Mgr., (for mail), Flax-li-num Insulating Co., 133 W. Washington St., Chicago, and 1044 Asbury Ave., Evanston, Ill.
MASON, Orion Augustus, (Associate 1922), Vice-Pres. and Sales Mgr., Homer & Perkins Co., Oliver St., Boston, and (for mail), 30 Vista Ave., Auburndale, Mass.
MASON, Ray B., (1925), Engr., (for mail), Kewanee Boiler Co., 2014 Wyandotte St., and 2940 Forest Ave., 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), Pres., (for mail), A. Mathis & Sons, Inc., 3155 Shields Ave., and 9151 S. Hoyne Ave., Chicago, Ill.
MATHIS, Henry, (1921), New York Blower Co., 2248 S. Halsted St., and (for mail), 143 West 71st St., 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. and Gen. Supt., (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., 220 Devonshire St., Boston, and 48 Dana St., Cambridge, Mass.
MATTHIESSEN, H. G. F., (1923), Sales Engr., Hoffman Specialty Co., 512 Fifth Ave., New York, N. Y., and (for mail), 179 Renner Ave., Newark, N. J.
MATTHEWS, John K., (1923), Morgan Htg. & Plbg. Co., Box 843, Charleston, W. Va.
MATZEN, Harry B., (1919), Mgr., Carrier Engrg. Corp., 923 Union Trust Bldg., and 2642 N. Moreland Blvd., Cleveland, O.
MAUER, William J., (1919), Sales Engr., Dwyer Equipment Co., 4534 W. North Ave., Chicago, and (for mail), 2624 Central St., Evanston, Ill.
MAUPAI, Ralph G., (Associate 1925), Pres., R. G. Maupai Co., 73 South St., Jersey City, and (for mail), 219 Eighth St., West New York, N. J.
MAURER, Edward D., (1921), Secy. and Treas., Maurer Bros. Co., 8600 Detroit Ave., Cleveland, and (for mail), 1527 Mars Ave., Lakewood, O.

MAY, Edwin A., (1906), 171 N. Kenilworth Ave., Oak Park, Ill.
MAYER, Robert S., (1911), Br. Sales Mgr., (for mail), *Heggie-Simplex Boiler Co.*, 2026 East 22nd St., and 9327 Amesbury Ave., Cleveland, O.
MEAD, Edward A., (1926), Sales Dept., Nash Engrg. Co., South Norwalk, Conn.
MEAD, Walter R., (1924), Sales Repr., Hoffman Specialty Co., Waterbury, Conn., and (for mail), 711 Highland Ave., San Mateo, Calif.
MEADOWS, Frank H., (1923), The Meadows Heating Co., 94 Second St., Milwaukee, Wis.
MEARA, John J., (Junior 1925), Estimator and Engr., Hunt Heating Co., 1515 Olive St., and 2733 Gamble St., St. Louis, Mo.
MEDWAY, Fred J., (Associate 1919), Mgr., (for mail), Johns-Manville, Inc., Madison Ave. and 41st St., New York, N. Y., and 803 Boulevard, E., Weehawken, N. J.
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), Gen. Mgr., Htg. Systems & Supply Co., 169 N. May 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), 131 South 12th St., Newark, and 2 Garfield Place, E. Orange, N. J.
MERRILL, Carle J., (1919), Treas., (for mail), C. J. Merrill, Inc., 54 St. John St., and 15 Longfellow St., Portland, Me.
MERRITT, C. J., (1925), Andersen Meyer & Co., Ltd., 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), Partner, Mervine Bros., 208 S. Seventh St., and (for mail), 5852 N. Fifth St., Philadelphia, Pa.
MERWIN, Gile E., (Junior 1923; 1924), Htg. Engr., (for mail), Rockford Brass Works, and 1225 N. Church St., Rockford, Ill.
MESSMER, George E., (Junior 1925), Htg. Engr., (for mail), Bridge & Beach Mfg. Co., 4204 N. Union Blvd., and 3020 Walton Place, St. Louis, Mo.
MESTON, A. B., (Associate 1925), 201 W. Second St., Des Moines, Ia.
MEWSHAW, James P., (1923), C. A. Dunham Co., 605-6 Hill Bldg., 17th and Eye St., N.W., and 2700 35th Place, N.W., Washington, D. C.
MEYER, Hans J., (1919), (Council 1922), Pres., (for mail), Chas. L. Pillsbury Co., 1200 Second Ave., S., and 2736 Hennepin Ave., Minneapolis, Minn.
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 Webster Hall, 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), 258 S. Van Pelt St., Philadelphia, Pa.
MEYERS, Samuel H., (Associate 1924), Meyers Bros., 219 Hale St., and 1502 Virginia St., Charleston, W. Va.
MEYERING, Archer S., (1922), Htg. and Vtg. Engr., (for mail). Br. Mgr., C. A. Dunham Co., 1721½ Carey Ave., and 1211 West 31st St., *Cheyenne, Wyo.*
MICHAEL, L. A., (1921), Htg. and Vtg. Engr., 414 W. Colfax Ave., Denver, Colo.
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. Engr., Bridgman Co., 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), Sales Engr., Illinois Engrg. Co., 21st St. and Racine Ave., Chicago, Ill., and (for mail), 744 Lafayette Ave., S.E., Grand Rapids, Mich.
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., and Allerton Club, Chicago, Ill.
MILLER, Max Paul, (1911), (for mail), W. D. Cashin & Co., 35 Hartford St., Boston, and 12 Byfield Rd., Waban, Mass.
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 Woodhaven, L. I., N. Y.
MILLET, Tolbert G., (Junior 1921), Piping Engr., Pennsylvania R. R., Harrisburg, and (for mail), Wormleysburg, Pa.
MILLER, William C., (1918), Pres., (for mail), Htg. Specialties Co., 10 South 18th St., Philadelphia, and Collegeville, Pa.
MILLIKEN, James H., (1923), Chicago Mgr., (for mail), Reed Air Filter Co., 140 S. Dearborn St., Chicago, and 618 Hinman Ave., 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., 4004 Duncan Ave., St. Louis, and 434 Lee Ave., Webster Grove, Mo.
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., Rue du Faubourg, St. Honore, and (for mail), 10, Rue Gustave Dore, Paris (17 eme), France.
MOFFETT, William S., (1907), Consulting and Construction Engr., Staunton, Va.
MOLER, William H., (Junior 1923), Pacific Coast Br. Mgr., (for mail), Carrier Engrg. Corp., 911 Mateo St., Fresno, Calif.

MOLO, Harold E., (1922), Mgr., (for mail), Linehan & Molo, 135 W. Fifth St., and 1018 W. Fifth St., Dubuque, Ia.
MOLTZ, George N., (Associate 1925), Sales Engr., Standard Heater Co., 315 Pearl St., Hartford, Conn.
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., 1320 Olive St., Philadelphia, Pa., and 15 N. Chelsea Ave., Atlantic City, N. J.
MONIN, E. H., (1923), E. H. Monin, Inc., 70 Delaware Ave., Buffalo, N. Y.
MONROE, Lewis O., (Junior 1917; Associate 1925), Gen. Mgr., (for mail), Clarage Fan Co., and 2415 S. Westnedge St., Kalamazoo, Mich.
MONTAGNA, C. J., (1924), Owner, (for mail), 2913 Colonial Ave., and 1215 DeBree Ave., Norfolk, Va.
MONTGOMERY, W. Ray, (Associate 1923), Co-Partner, Montgomery Bros., 500 N. Dearborn St., Chicago, Ill.
MOODY, Lawrence E., (1919), Engr., (for mail), Isaac H. Francis, 1520 Locust St., Bonbright Bldg., Philadelphia, Pa., and 237 Jefferson Ave., Haddonfield, N. J.
MOON, L. Walter, (1915), Engr., (for mail), Bradley Htg. Co., 3834 Olive St., and 6069 Cates Ave., St. Louis, Mo.
MOORE, Donald S., (1923), Treas., (for mail), Flexlume Sales Co., 122 W. Forsythe St., and 34 W. Ninth St., Jacksonville, Fla.
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, Josiah C., (1921), Consulting Equipment Engr., (for mail), Aero Alarm Co., 508 Thompson Bldg., and 2409 E. Prospect St., Seattle, Wash.
MOORE, Raymond Francis, (Associate 1926), Architect, Cedar Rapids, Ia.
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., 1300 Jefferson Ave., Buffalo, N. Y.
MORGAN, C. Stanley, (Associate 1919), (for mail), 445 W. Larned St., and 14595 Harbord Rd., Detroit, 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), Vice-Pres. and Secy., (for mail), Morgan-Gerrish Co., 808 LaSalle Ave., and 134 West 49th St., 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.
MORRIS, C. Raymond, (1921), (for mail), 55 Lexington Ave., Passaic, and 381 20th Ave., Paterson, N. J.
MORROW, Charles F., (Associate 1919), Mgr., (for mail), National Radiator Co., 1509 Arrett Bldg., Wood and Fourth Ave., Pittsburgh, and Wampum, Pa.
MORSE, C. T., (1921), Sales Mgr., American Blower Co., 6004 Russell St., 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.
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), Secy., (for mail), Board of Education, 705 First Ave., and 220 16th Ave., Cedar Rapids, Ia.
MOTT, Abram C., Jr., (1921), Pres., (for mail), Abram Cox Co., American and Dauphin Sts., Philadelphia, and "The Woods," Lansdale, Pa.
MOUAT, Thomas G., (1914), Pres., (for mail), The Mouat Vapor Htg. Co., 1246 W. Fourth St., and 360 East 105th St., Cleveland, O.
MOULDER, Albert W., (1917), Chief Engr., (for mail), Grinnell Co., Inc., Dana and Paige Ave., and 74 Roosevelt Ave., Warren, O.
MOULTON, David, (1926), Mech. Engr., (for mail), Monks & Johnson, 99 Chauncy St., and 30 Meridian St., Malden, Mass.
MOWER, William P., (1924), Htg. Engr., (for mail), Warren Webster & Co., 220 Devonshire St., Boston, and 48 Middlesex Ave., Swampscott, Mass.
MOYNIHAN, John C., (Junior 1925; Associate 1926), 136 Myrtle St., Indian Orchard, 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), Engr., Muir & Brooks, 136 W. Lake St., Chicago, and (for mail), 234 S. Scoville Ave., Oak Park, Ill.
MUNDER, J. F., Jr., (Junior 1924), Sales Engr., American Blower Co., 50 Church St., and 1738 University Ave., New York, N. Y.
MUNIER, Leon L., (Junior 1915; 1919), Secy. and Treas., (for mail), Wolff & Munier, Inc., 222 East 41st St., New York, and 610 Lafayette Ave., Mt. Vernon, N. Y.
MUNRO, Edward A., (1920), Htg. and Vtg. Engr., (for mail), 506-7 Metropolitan Bk. Bldg., Washington, and 3837 Livingston St., Chevy Chase, Washington, D. C.
MUNROE, Edward K., (1904), Engr. Salesman, Republic Boiler & Radiator Co., Union St., and 5924 Bellona Ave., Baltimore, Md.
MUNSON, Morris G., (1925), Sales Repr., Herman Nelson Corp., (for mail), 501 Essex Bldg., and 2811 Dean Blvd., Minneapolis, Minn.
MURCH, Greenwood E., (1923), Richardson Boynton Co., 3639 S. Ashland Ave., and (for mail), Chicago Athletic Assoc., Box 120, Chicago, Ill.
MURPHY, Edward T.,* (1915), Vice-Pres. and Gen. Sales Mgr., (for mail), Carrier Engrg. Corp., 2021 Land Title Bldg., and 4621 Osage Ave., Philadelphia, Pa.
MURPHY, Howard C., (1923), Vice-Pres., (for mail), Reed Air Filter Co., Inc., 215 Central Ave., and 2114 Edgehill Rd., Louisville, Ky.
MURPHY, J., (Associate 1924), 304 Main St., Cambridge, Mass.
MURPHY, Joseph Richard, (Associate 1925), Asst. to Pres., Thermal Appliance Co., Inc., 342 Madison Ave., New York, and (for mail), Kew Beverly B-2, Kew Gardens, L. I., N. Y.
MURPHY, William A., (1926), Sales Engr., (for mail), *Hoffman Specialty Co.*, 25 West 45th St., New York, N. Y., and 23 South 17th St., Harrisburg, Pa.
MURPHY, William R., (1911), Pres. and Treas., American Htg. & Vtg. Co., 804 Times Dispatch Bldg., Richmond, Va., 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), Steam Htg. Contractor, (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), 111 Old Lancaster Rd., Bala, Pa., and 5629 32nd St., N.W., Washington, D. C.
MYERS, George W. F., (Junior 1923), Asst. Sales Mgr., (for mail), York Htg. & Vtg. Corp., 1502 Locust St., and 2233 South 15th St., Philadelphia, 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), Sales Engr., 22 Beverly Ave., Albany, N. Y.
NAROWETZ, Louis L., Jr., (Associate 1912), Contracting, Secy., (for mail), Narowetz Htg. & Vtg. Co., 1711-1717 Maypole Ave., Chicago, and Park Ridge, Ill.
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), Vice-Pres. and Sales Mgr., (for mail), Standard Asbestos Mfg. & Insulation Co., and 3204 Windsor Ave., Kansas City, Mo.
NEILER, Samuel G., (1898), Sr. Member, (for mail), Neiler, Rich & Co., Consulting & Designing Engineering, 431 S. Dearborn St., Chicago, and 737 N. Oak Park Ave., Oak Park, Ill.
NEITZEL, Carl W., (1921), Mgr., The C. W. Neitzel Co., 1327 East 105th St., 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 O., (1923), Carstens Bros., Ackley, Ia.
NELSON, Harold A., (1926), Supervising Engr., Nelson & Wylie, Sixth and Olive Sts., and (for mail), 1009 S. Plymouth Blvd., Los Angeles, 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), Engr. and Sales Repr., Ralph L. Nelson, 506 Empire State Bldg., and 218 W. Buckeye, Spokane, Wash.
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., 213 N. Vermont Ave., and 212 S. Victoria Ave., Atlantic City, N. J.
NESBITT, John J., (1923), Pres., (for mail), J. J. Nesbitt, Inc., 213 N. Vermont Ave., Atlantic City, N. J., and Rockfield Farm, Ambler, Pa.
NESDAHL, Ellert, (1915), Sales Engr., Carrier Engrg. Corp., 1032 Burnham Bldg., Chicago, Ill.
NEWCOMB, Raymond, (Junior 1924), New England Mgr., Kewanee Boiler Co., Inc., 1140 Little Bldg., Boston, and (for mail), 15 Walnut St., Newtonville, Mass.
NEWPORT, Charles F.,* (1906), Sales Engr., Weil, McLein Co., Michigan City, Ind., and (for mail), 10001 Longwood Drive, Chicago, Ill.
NICELY, John Eyster, (Associate 1925), Sales Mgr., Corbit Bros. Plbg. & Htg. Co., 147-151 N. Fifth St., and (for mail), 406 Green Terrace, Reading, Pa.
NICHOLLS, Percy,* (1920), Fuel Engr., (for mail), U. S. Bureau of Mines, and 273 N. Craig St., Pittsburgh, Pa.
NICHOLS, George B., (1915), (Council 1919-1920), c/o Hagerman-Harris, Boston, Mass.
NICOL, Norman C., (1923), Field Engr., National Tube Co., 71 Broadway, New York, N. Y.
NIESTRATH, W. H., (Associate 1921), 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), 5547 Magnolia Ave., Chicago, Ill.
NOBBS, Walter W., (1919), 50 Fairhazel Gardens, London, N.W., 6, Eng.
NOBIS, Harry M., (1914), Htg. Engr., 2010 East 102nd St., Cleveland, and (for mail), 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., (for mail), Virginia Engrg. Co., 322-330 28th St., and 319 54th St., Newport News, Va.
NOLAND, Ralph W., (1914), Consulting and Mech. Engr., 824 Lafayette Life Bldg., Lafayette, and 1001 Roberts St., Lafayette, Ind.
NOLL, William F., (1924), 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 St., Chicago, Ill.
NORRIS, Edward, (1909), Utica Heater Co., Utica, N. Y.
NORRIS, James K., (1920), Vice-Pres., (for mail), Utica Heater Co., and 1 Jewett Place, Utica, N. Y.
NORTON, Frederick W., (Junior 1922; Associate 1925), Engr., Gillis & Geoghegan, 537 W. Broadway, New York, and 47 Rokeby Place, Livingston, S. I., N. Y.
NULSEN, Carl A., (1919), Engr., (for mail), Hanley & Co., 6 N. Clark St., and 931 Ainslie St., Chicago, Ill.
NUNAN, John F., (Junior 1921; Associate 1925), Foreman, (for mail), Jas. Spear Stove & Heater Co., 1823 Market St., and 238 W. Highland Ave., Chestnut Hill, Philadelphia, Pa.
NUSBAUM, Lee,* (1915), Engr., (for mail), Pennsylvania Engrg. Co., 1119 N. Howard St., and 315 Carpenter Lane, Philadelphia, Pa.

O

OAKS, Orion 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.
OBERT, Casin W., (1916), (Secy. 1916-1923), Secy. to A. S. M. E. Boiler Code Committee, 29 West 39th St., New York, and (for mail), 122 N. Columbus Ave., Mt. Vernon, N. Y.
O'BRIEN, J. H., (1923), Chicago Dist. Mgr., (for mail), American Blower Co., 140 S. Dearborn St., and 6525 Glenwood Ave., Chicago, Ill.
O'CONNELL, Edward D., (Associate 1925), Htg. Engr., Robt. Scott, Inc., 1512 Vine St., and (for mail), 1432 North 53rd St., Philadelphia, Pa.
O'CONNELL, Presly M., (1916), Repr., Hoffman Specialty Co., and (for mail), 5749 31st Ave., N.E., Seattle, Wash.
O'CONNOR, Joseph M., (1923), C. A. Dunham Co., 302 Orpheum Bldg., and (for mail), 421 Sedgwick Bldg., Wichita, Kans.
O'DONNELL, Thomas J., (1920), Secy. and Treas., (for mail), William H. McKiever, Inc., 247 West 13th St., and 31 Park Terrace West, New York, N. Y.
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.
OHMES, Arthur K.,* (1913), (Council 1915; 2nd Vice-Pres. 1916; 1st Vice-Pres. 1917), Consulting Engr., 101 Park Ave., New York, N. Y.
OLSEN, A. J., (Junior 1924), C. J. Olsen, 109-11 Center St., and 452 Center St., Winona, Minn.
OLSEN, Carlton F., (Junior 1920; Associate 1925), Combustion Engr., 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), 3133 N. Keating Ave., Chicago, Ill.
OLSON, Robert G., (1923), Milwaukee Mgr., (for mail), American Blower Co., 911 Majestic Bldg., and 245 Prospect Ave., Milwaukee, Wis.
OLVANY, William J., (1912), Engr. and Contractor, 100 Charles St., New York, N. Y.
O'NEILL, James Walter, (Junior 1925), Chief Engr., The Trane Co., 21-23 River St., and (for mail), 207 McRobert Ave., Toronto, Ont., Can.
O'NEILL, Peter, (1920), Treas. and Mgr., Bartley-O'Neill Co., 224 Third Ave., Pittsburgh, Pa.
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, Merrill J., (1917), Pres. and Mgr., Orr Co., (for mail), 513 Jackson St., and 1815 Jackson St., Sioux City, Ia.
ORTH, John W., (1919), Pres., Orth Plbg. Co., 509 Columbia St., Lafayette, Ind.
OSBORNE, Gurdon H., (1922), Gen. Mgr., (for mail), The Vtg. & Blow Pipe Co., Ltd., 144 Inspector St., and 275 Addington St., Apt. No. 7, Montreal, Que., Can.
OSBORNE, Maurice M., (1925), Advertising Counsel for Technical Products, Osborne & Co., 755 Boylston St., and (for mail), 367 Beacon St., Boston, Mass.
OSMON, Thomas R., (1916), Htg. and Vtg. Engr., Spohn Htg. & Vtg. Co., 1775 East 45th St., and (for mail), 851 Paxton Rd., Cleveland, O.
OSTRANDER, Lewis F., (1923), Vice-Pres. and Htg. Engr., O-E Specialty Mfg. Co., 8-12 Keefe Ave., and (for mail), 411 Newberry Blvd., Milwaukee, Wis.
OSWALD, Walter L., (1919), Sales Engr., Crane Co., 23 West 44th St., New York, and (for mail), 562 Hutchinson Blvd., Mt. Vernon, N. Y.
OTIS, Gerald E., (1922), Vice-Pres., (for mail), The Herman Nelson Corp., and 1921 23rd Ave., Moline, Ill.
OTT, Oran W., (1925), Consulting Mech. Engr., (for mail), 13004 Washington Bldg., and 123 S. Virgil Ave., Los Angeles, Calif.
OTTO, Robert W., (1912), Chief Engr., Andrews Heating Co., 2529 University Ave., S.E., Minneapolis, and (for mail), 2147 Carroll Ave., St. Paul, Minn.

P

PADGINTON, George, (1919), Supt. of Htg. and Plbg., Board of Education, 906 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), Vice-Pres. and Gen. Mgr., Bayley Mfg. Co., 732 Greenbush St., Milwaukee, and 119 Warren Ave., Wauwatosa, Wis.
PAGE, Sidney H., (1923), Mech. and Elec. Engr., Charles Foster, 612 Sellwood Bldg., and (for mail), 5407 London Rd., Duluth, Minn.
PAGET, B. K., (Junior 1924), L. J. Wing Mfg. Co., 352 West 13th St., New York, N. Y., and (for mail), 20 E. Park St., Newark, N. J.
PAINE, Kenneth A., (Junior 1925), Mgr., Paine Heating Co., 217 S. State St., and (for mail), P. O. Box, 13, Jackson, Miss.
PAINE, Leonard G., (1920), Philadelphia Mgr., (for mail), Dunham Vacuum Heating System, 112 South 16th St., and 5915 Carpenter St., Philadelphia, Pa.
PAINTER, David H., (Associate 1924), Salesman, Hoffman Specialty Co., and (for mail), 3124 Forest Ave., Sioux Apts., Kansas City, Mo.
PALMER, Geo. J., (1923), (for mail), 14-16 W. Market St., and 419 Walnut St., W. Chester, Pa.
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, and (for mail), 4321 Charlotte St., Kansas City, Mo.
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), 642 West 172nd St., New York, N. Y.
PARTLAN, James W., (1916), (for mail), 13900 Goddard Ave., and 478 Algonquin Ave., Detroit, Mich.
PASK, Raymond J., (Junior 1924), Consulting Engr., Crytser & Pask, Tribune Tower, and (for mail), 14 S. Homan Ave., Chicago, Ill.
PATERSON, G. E., (1926), Owner, Paterson Htg. Co., 28 Waugoo St., Oshkosh, Wis.
PATERSON, James S., (1922), Htg. Engr., (for mail), Board of Education 155 College St., and 23 Norton Ave., Toronto, Ont., Can.
PATERSON, Wm. B., (Junior 1920; Associate 1921), Asst., H. H. Angus, Consulting Engr., 2 Bloor St., W., and (for mail), 198 St. Germain Ave., Toronto, Ont., Can.
PATORNO, Sullivan A. S., (1923), Htg. and Vtg. Engr., (for mail), Meyer, Strong & Jones, Inc., 101 Park Ave., and 150 East 50th St., New York, N. Y.
PATTERSON, D. Finley, (Junior 1925), Engr., Vapor Htg. Co., (for mail), 215 South 17th St., and 6428 N. Woodstock St., Philadelphia, Pa.
PAULDING, Lewis Grant, (1926), Partner, (for mail), Frank Paulding & Son, 405 Lexington Ave., and 8733 117th St., New York, N. Y.
PEACOCK, James K., (1921), New York Mgr., (for mail), Hoffman Specialty Co., 512 Fifth Ave., New York, and 440 Fowler Ave., Pelham Manor, N. Y.
PEARCE, C. E., (1911), Chief Engr., Guilbert & Betelle, Architects, Chamber of Commerce Bldg., Newark, and (for mail), 1255 Clinton Place, Elizabeth, N. J.
PEARSON, Fred L., (1925), Consulting Engr., (for mail), 6 N. Michigan Ave., and 7702 Eastlake Terrace, Chicago, Ill.
PEARSON, Harry D., (1917), Pres. and Mgr., (for mail), Michigan Warming & Vtg. Co., 363 Houseman Bldg., and 700 College St., S.E., Grand Rapids, Mich.
PEASE, Harrison H., (Associate 1922), Commercial Trust Bldg., and (for mail), 8409 Shawnee St., Chestnut Hill, Philadelphia, Pa.
PEASE, John G., (1917), Owner, John G. Pease Co., 310 Minor Bldg., and 1718 East 59th St., Kansas City, Mo.
PECKHAM, Randolph R., (1919), Supt., (for mail), 650 W. Baltimore Ave., and 3018 Hograth Ave., Detroit, Mich.
PEEBLES, John K., (Junior 1924; Associate 1925), Peebles & Ferguson, 733 Law Bldg., Norfolk, Va.
PENHALLEGON, R. L., (1925), Burnham Boiler Corp. of Calif., 1385 Harrison St., San Francisco, Calif.
PENNELL, S. Howard, (1925), Member of Firm, (for mail), William Macy Stanton, Archt., S.W. Cor. Broad and Chestnut Sts., Philadelphia, Pa.
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), Associate Engr., (for mail), Charles R. Ammerman, Consulting Engr., 925 Continental Bk. Bldg., and 4507 Carrollton Ave., Indianapolis, Ind.
PERKINS, Fred C., (Associate 1923), Perkins-LeNoir Co., 1068 Drexel Bldg., Philadelphia, Pa.
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 Gen. Mgr., (for mail), Htg. and Vtg. Magazine, 1123 Broadway, New York, N. Y., and 216 11th St., Hoboken, N. J.
PETERSON, Evan A., (1923), Sales Engr., Crane, Ltd., 386 Beaver Hall Sq., and 122 Kenaston Rd., Town of Mt. Royal, Montreal, Que., Can.
PETERSON, H. K., (1920), Htg. Engr., Nelson Co., 2604 Fourth Ave., and (for mail), 14572 Coyle Ave., Detroit, Mich.
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, John Frederick, (Junior 1925), Mech. and Htg. Engr., (for mail), Standard Heater Co., and 346 Louisa St., Williamsport, Pa.
PFEIFFER, Jos. F., (1921), Owner, (for mail), 1140 California St., and 717 Vine St., Denver, Colo.
PFLUGRADT, Allen G., (Junior 1926), Partner, (for mail), Pflugradt Heating Co., 979 Grant St., and 1588 Murray Ave., Milwaukee, Wis.
PFUHLER, John L., (Junior 1923; Associate 1925), Plbg. and Htg., 600 Manor Rd., S.I., N. Y.
PHEGLEY, Frank G., (1913), (Council 1918-1919), Research Engr., Hart-Crouse Co., 301 Turner St., Utica, N. Y.
PHELPS, Glen H., (Associate 1925), 238 South 11th St., Lincoln, Nebr.
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.
PHILLIPS, Lee, (1920), Htg. Engr., 308 Ferguson Bldg., 319 Third Ave., Pittsburgh, and Terrace Ave., Carnegie, Pa.
PICKER, Frederick 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., 510 Rialto Bldg., and 8003 Canton Ave., Vivita Park, St. Louis, Mo.
PIERCE, Edward F., Jr., (Junior 1925), Sales Engr., Hoffman Specialty Co., 72 Lynn Fells Parkway, Melrose, Mass.
PIERON, Anton, (1921), Htg. and Vtg. Engr., Warren & Wetmore, 16 East 47th St., New York, and (for mail), Sterling Place, St. Albans, N. Y.
PINDER, Percy H., (1919), Merchant, (for mail), Standard Steam Specialty 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 5012 Forest Ave., Kansas City, Mo.
PIPER, Albert, (1920), Plbg. and Htg. Contracting, (for mail), Piper Bros., 340-346 N. Broad St., Trenton, N. J.
PISEL, Joseph W., (Junior 1921; Associate 1926), Engr., I. H. Francis, Consulting Engr., 1520 Locust St., Philadelphia, and (for mail), 53 Brookline Blvd., Upper Darby P. O., Pa.
PITCHER, Lester J., (Junior 1924), Chief Draftsman, Illinois Engrg. Co., 21st and Racine Ave., and (for mail), 7214 E. End Ave., Chicago, Ill.
PITTELKOW, Arthur G., (1907), Pres., Pittelkow Htg. & Engrg. Co., (for mail), 2340 W. Lafayette Blvd., and 355 Chalmers Ave., 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 53 East 66th 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.
PLAYFAIR, George A., (Associate 1924), Mgr., (for mail), Johnson Temperature Regulating Co., 147 Church St., and Stop 33, Kingston Rd., 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.
POOL, Sterling H., (1913), Pres., (for mail), Howard F. Pool Co., 22 Market St., Lynn, and 60 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 293 Keystone Ave., River Forest, Ill.
PORTRUDE, William M., (Junior 1926), Plbg. and Htg. Salesman, Andersen, Meyer & Co., and 115 Pere Robert, Shanghai, China.
POSEY, James, (1919), Consulting Engr., (for mail), 1309 Lexington Bldg., and 4005 Liberty Heights Ave., Baltimore, Md.
POTTINGER, C. T., (1917), Dist. Mgr., American Blower Co., 614-615 Bona Allen Bldg., Atlanta, Ga.
POWERS, Fred I., (1920), Salesman, P. O. Box 324, Bozeman, Mont.
POWERS, Fred W., (1911), (Council 1918-1919), Treas. and Gen. Mgr., (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.
PREBLE, J. Jarvis, (1919), Vice-Pres., (for mail), Spray Engrg. Co., 60 High St., Boston, and 38 Bowdoin St., Newton Highlands, Mass.
PRESDEE, Cliff W., (Associate 1926), Western Mgr., (for mail), Htg. & Vtg. Magazine, 105 S. Dearborn St., and 7909 Eberhard Ave., Chicago, Ill.
PRICE, Frank E., (Associate 1922), Mgr. Htg. Dept., Standard Sanitary Mfg. Co., 1720 Blake St., and (for mail), 1544 Jasmine St., Denver, Colo.
PROBST, Alfred H., (1919), Sales Engr., (for mail), Morgan-Gerrish Co., 808 LaSalle Ave., and 2902 James Ave., S., Minneapolis, 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), Koithan & Pryor, 39 Cortlandt St., New York, N. Y., and 199 Roseville Ave., Newark, N. J.
PURCELL, Arthur J., (1914), Htg., Plbg. and Steam Specialty Engr., 631 New Britain Ave., Hartford, Conn.
PURCELL, Frederick C., (1926), Sales Engr., (for mail), F. C. Purcell & Co., 2847 Grand River Ave., and 1501 Virginia Park, Detroit, Mich.

PURCELL, Robert E., (1916), Htg., Vtg. and Plbg. Contractor, 1735 Willis Ave., W., and (for mail), 128 Avery Ave., Detroit, Mich.
PURDY, Alexander K., (1922), Pres., (for mail); Purdy, Mansell, Ltd., 63 Albert St., and 30 Glenrose Ave., Toronto, Ont., Can.
PURINTON, Dexter J., (Associate 1923), Head of Mech. Dept., (for mail), McKenzie, Voorhees & Gauline, 342 Madison Ave., New York, N. Y., and 23 Sachem Rd., Greenwich, Conn.
PURSELL, H. E., (1919), Br. Mgr., Kewanee Boiler Co., 1226-28 California St., Denver; and (for mail), 212 S. Tremont St., Kewanee, Ill.
PYLE, John W., (1919), Supt., (for mail), Peru Htg. Co., 30 W. Canal St., and 371 W. Third St., Peru, Ind.

Q

QUALTROUGH, Ben F., (Associate 1926), 928 Wyandotte St., 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., 14 North 12th St., and 3259 Geyer Ave., St. Louis, Mo.
QUESNEL, N. W., (1925), C. A. Dunham Co., Ltd., 14 Struchen Ave., and (for mail), 23 Carey Rd., Toronto, Can.
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), 202 Riverside Drive, New York, N. Y.
RALSTON, Louis T. M., (1926), Consulting Engr., (for mail), Ralston & Hattenhof, Inc., 52 Vanderbilt Ave., and 875 W. End Ave., New York, N. Y.
RANDOLPH, Charles H., (Junior 1926), Sales Engr., American Foundry & Furnace Co., 805 36th St., and 705 Bartlett Ave., Milwaukee, Wis.
RASMUSSEN, Einar, (Junior 1925; Associate 1926), Westinghouse Elec. & Mfg. Co., E. Pittsburgh, and (for mail), 414 Whitney Ave., Wilkinsburg, Pa.
RATHER, Max F., (1919), Cleveland Mgr., Johnson Service Co., 2028 East 22nd St., Cleveland, and 3098 Huntington Rd., Shaker Heights, O.
REARDON, J. Albert, (1921), Pres., (for mail), Reardon Bros. Co., 341 Union St., Lynn, and 18 Marion Rd., Clifton, Mass.
RECK, Anders B.,* (1899), Pres., (for mail), Reck Htg. Co., Ltd., 15, Esromgade, Copehagen, and 16, Christiansvej, Hellerup, Denmark.
REDERER, Benedict S., (1922), Mgr., (for mail), B. S. Rederer & Co., 513 Arrott Bldg., and 1515 Rockland Ave., Pittsburgh, Pa.
REED, John F., (Associate 1923), Vice-Pres., (for mail), Reed Air Filter Co., 50 Church St., New York, N. Y., and 63 Watchung Ave., Montclair, N. J.
REEDER, Charles L., (1911), Consulting Engr., (for mail), 916 N. Charles St., Baltimore, and 222 Longwood Rd., Roland Park, Md.
REEDER, Frank C., (Associate 1919), Factory Repr., The Fulton Co., and (for mail), 204 E. Oklahoma Ave., Knoxville, Tenn.
REESE, Henry L., (1923), Pres. and Gen. Mgr., (for mail), Keystone Plumbing & Htg. Co., 229 N. Sixth St., and 835 Pear St., Reading, Pa.
REEVES, Charles G., (1916), 257 W. Clapier St., Germantown, Philadelphia, Pa.
REICHWALD, Charles W., (1923), Htg. Engr., (for mail), C. W. Reichwald, Inc., 763 Paterson Ave., Jersey City, and 22 Adelina Place, North Bergen, N. J.
REINHARD, Edward L., (1919), Buffalo Br. Mgr., (for mail), American Radiator Co., 1807 Elmwood Ave., and 99 N. Lincoln Blvd., Buffalo, N. Y.
REPP, Harry L., (1922), Br. Mgr., U. S. Radiator Corp., 908 N. Senate Ave., and 525 S. Central Circuit, Indianapolis, Ind.
REUSS, Edward H., Jr., (Associate 1919; 1921), Htg. Contractor, (for mail), Edward H. Reuss, Jr., 30th and Race Sts., and Bryn Mawr and Woodbine Ave., Philadelphia, Pa.
REUTER, Albert G., (1922), Sales Engr., The Daly Co., 1425 16th St., and (for mail), 702 S. Corona St., Denver, Colo.
REYNOLDS, Harry A., (1925), Engr., S. J. Reynolds Co., Inc., 2223 Ogden Ave., and 721 N. Lotus Ave., Chicago, Ill.
REYNOLDS, Henry M., (1915), Vice-Pres., General Boilers Co., Waukegan, Ill.
REYNOLDS, Thurlow W., (1922), Engr., Clyde R. Place, Consulting Engr., Grand Central Terminal, New York, N. Y., and Portland Rd., Highlands, N. J.
RHODES, Solomon V., (1921), Supt. of Htg., (for mail), Farrell Htg. & Plumbing Co., 25 Houston St., and 45 E. Cain St., Atlanta, Ga.
RIBLET, William H., (Associate 1921), Eastern Div. Mgr., (for mail), C. A. Dunham Co., 101 Park Ave., and 32 West 40th St., New York, N. Y.
RICE, Clarence J., (Associate 1923), Pres., for mail), Sterling Engrg. Co., 1640 Holton St., Milwaukee, and 2425 Thompson Ave., Whitefish Bay, Wis.
RICE, William W., (1915), Contracting Engr., Mellon Co., 4417-19 Ludlow St., Philadelphia, and (for mail), 830 Morgan Ave., Upper Darby, Del. Co., Pa.
RICHARDS, Frank A., (1920), Sales Engr., Richard & Wolfe, Sales Reprs., The Herman Nelson Corp., and (for mail), 832 Atlas Bldg., Columbus, O.
RICHARDS, Samuel F., (1915), Eastern Sales Repr., H. A. Thrush & Co., Peru, Ind., and (for mail), 335 W. Riverview Ave., Bellevue Br., Pittsburgh, Pa.
RICHARDSON, A. Howard, (Associate 1922), 2nd Vice-Pres., (for mail), Richardson & Boynton Co., 3639 S. Ashland Ave., and 1302 Ritchie Court, Chicago, Ill.
RICHARDSON, D. Rait,* (1915), Pres., (for mail), Richardson & Boynton Co., 260 Fifth Ave., and 299 Park Ave., New York, N. Y.
RICKER, John J., (1925), Pres., (for mail), Ricker & Kneblin, Inc., 528-530 Jefferson St., 40 18th St., W. New York, N. J.
RIDLER, Harry C., (1919), Plbg., Htg. and Vtg. Engr. and Mgr., (for mail), 310 West 33rd St., and 3248 Pleasant Ave., Minneapolis, Minn.
RIETZ, Elmer W., (1923), Asst. Sales Mgr., (for mail), Powers Regulator Co., 2720 Greenview Ave., and 5246 Glenwood Ave., Chicago, 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., Research Dept., American Radiator Co., 1807 Elmwood Ave., and (for mail), 815 Tonawanda St., Buffalo, N. Y.

RINKENBERGER, George, (1924), Sales and Htg. Engr., (for mail), Paul Plumbing & Htg. Co., 811 Railroad St., and 831 Franklin St., Johnstown, Pa.
RITCHIE, Edmund J., (1923), Gen. Sales Mgr., (for mail), 183 Madison Ave., New York, and 19 Grace St., Brooklyn, N. Y.
RITCHIE, William, (1909), 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 589 Fourth St., Brooklyn, N. Y.
RIVARD, Melvin M., (Junior 1926), Sales Engr., American Radiator Co., and (for mail), 5829 Woodland Ave., Kansas City, Mo.
ROBB, John M.,* (1913), Htg. Engr., 1513 Columbia Terrace, 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.
ROBERTS, Wm. L., (1923), 183 Harrison Ave., Boston, and (for mail), 85 Baker St., W. Roxbury, Mass.
ROBERTSON, George A., (1902), Supervising Inspector Htg. and Vtg.. Div., (for mail), Board of Education, Bureau of Plant Operation, 131 Livingston St., and 1081 East 39th St., Brooklyn, N. Y.
ROBERTSON, John M., (Junior 1926), Sales Engr., E. K. Campbell Htg. Co., 2445 Charlotte St., Kansas City, and (for mail), 7123 Clayton Rd., St. Louis, Mo.
ROBINSON, Albert G., (1924), (for mail), 4 Thomson Block, and 18 Harrison Ave., Glen Falls, N. Y.
ROBINSON, S. Whitmore, (Associate 1902; 1910), Consulting Engr., 10 Kilburn Priory, London, N.W., Eng.
ROCKART, Edward R., (1921), Mech. Engr., Minneapolis Board of Education, 245 Ninth Ave., N., Minneapolis, and (for mail), 1173 Arkright St., St. Paul, Minn.
RODMAN, Robert W., (1922), Supt. of Plant Operation, (for mail), Dept. of Education, 500 Park Ave., and 2102 Broadway, New York, N. Y.
ROEBUCK, William, Jr., (1917), Sales Engr., (for mail), The R. T. Coe Cos., 522 Cutler Bldg., and 1625 East Ave., Rochester, N. Y.
ROGERS, A. Carle, (1921), Consulting Engr., 752 Euclid Ave., Toledo, O.
ROGERS, C. W., (1921), Chief Engr., (for mail), The New York Blower Co., 2246 S. Halsted St., and 3156 Cambridge St., Chicago, Ill.
ROGERS, George Howell, (1920), Salesman and Htg. Engr., International Heater Co., Linthicum Heights, Md.
ROLLINS, Fred D., (1919), 4107 Washington Blvd., Chicago, Ill.
ROLLINS, Lewis M., (1916), Morris & Co., *Union Stock Yards, and (for mail),* 218 N. Milton St., St. Paul, Minn.
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., 1807 Elmwood Ave., Buffalo, and Eggertsville, N. Y.
ROSEBROUGH, Robert M., (1920), Br. Mgr., (for mail), L. J. Mueller Furnace Co., 1409 Olive St., and 5502 Maple Ave., St. Louis, Mo.
ROSENBACH, Rudolph G., (1920), Sales Engr., (for mail), Warren Webster & Co., 549 W. Washington St., Chicago, and 343 N. York St., Elmhurst, Ill.
ROSS, John O., (1920), Pres., (for mail), J. O. *Ross Engrg. Corp.,* 30 East 42nd St., and 875 W. End Ave., New York, N. Y.
ROSSMAN, Vincent D., (1919), Secy., (for mail), Modern Htg. Co., 3935 Olive St., and 2365 Klemm St., St. Louis, Mo.
ROTHROCK, John T., (1920), Supt. Mech. Engr., Thompson-Starrett Co., Packard Bldg., Philadelphia, Pa.
ROTZ, John M., (1918), Member of firm, (for mail), Snider & Rotz, Consulting Engrs., 703 Merchants Bk. Bldg., and 3930 Broadway, Indianapolis, Ind.
ROW, Oliver M., (1912), Director, Royles, Ltd., Irlam, near Manchester, Eng.
ROWE, William A., (1921), Chief Engr., American Blower Co., 6004 Russell St., and 7477 Churchill Ave., 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.
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., 1627 Fourth Ave., and 319 Garfield St., Seattle, Wash.
RUDIO, H. M., (1921), Carrier Engrg. Corp., 923 Union Trust Bldg., Cleveland, O., and 142 Winspear Ave., Buffalo, N. Y.
RUFF, DeWitt C., (1922), Co-Partner, (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.
RUPPERT, E. H., (Associate 1923), (for mail), Excelso Specialty Works, 85 Eastern Parkway, Brooklyn, and 210 East 45th St., New York, N. Y.
RUSSEL, Donald Peters, (1925), Htg. and Vtg. Engr., Thomas Haverty Co., 316 E. Eighth St., Los Angeles, and 451 Edwards Ave., Wilmar, Calif.
RUSSELL, Hugh C., (1911), Inspector, Mech. and Elec. Engr., Supervising Arch. Office, (for mail), U. S. Treasury Dept., 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., 500 N. Dearborn St., Chicago, Ill., and 2484 Pingree, Detroit, Mich.
RUSSELL, Willard E., (1921), Mgr., C. A. Dunham Co., 219 E. Hanover St., Trenton, N. J.
RUSSELL, William Arthur, (Charter Member), *Pres., W. A. Russell & Co.,* Grand Central Terminal Bldg., 70 East 45th St., New York, and 563 Palisade Ave., Yonkers, N. Y.
RUSSELL, William L. A., (Associate 1925), St. Louis Sales Mgr., (for mail), Skinner Bros. Mfg. Co., 1474 S. Vandeventer St., and 5605 Etzel Ave., St. Louis, Mo.
RYAN, Harry J., (1922), Consulting Engr., 91 *Elm St., Albany,* N. Y.
RYAN, Henry B., (1920), Vice-Pres., (for mail), Barry, Byrne & Ryan Co., 104 S. Michigan Ave., Chicago, and 170 Fuller Lane, Winnetka, Ill.

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., and 5814 Maple Ave., St. Louis, Mo.
SAKOUTA, Mathieu L., (1924), Consulting Engr. Expert, Gavan, Simanskaia 4, Leningrad, Russia.
SAMUELS, Sidney, (Junior 1925), Secy., (for *mail), Wholesale Htg. Supplies, 262 West 145th* St., and 1673 University Ave., 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.
SANVILLE, Charles P., (1922), Sales Engr., Schade Valve Mfg. Co., 2527 N. Bodine St., and 1456 Sparks St., Philadelphia, Pa.
SARGENT, Leonard F., (1919), Mgr., National Htg. & Vtg. Co., P. O. Box 103, Wausau, Wis.
SAULSON, Saul, (1916), Mech. Engr., Albert Kahn, Inc., 1000 Marquette Bldg., and 2491 W. Euclid, Detroit, Mich.
SAVILLE, Thos. H., (1924), (for mail), International Correspondence Vtg. Schools, and 1121 Lafayette St., Scranton, Pa.
SAWADE, Carl A., (Associate 1920), Mgr. Boiler Sales, (for mail), Continental Heater Corp., Dunkirk, and 35 Curtis Place, Fredonia, N. Y.
SAWDON, Will M., (1920), Prof. Exper. Engrg., (for mail), Cornell Univ., and 1018 E. State St., Ithaca, N. Y.
SCANLON, John J., (Associate 1924), Ames Iron Works, 1035 Commercial Trust Bldg., and 30 South 54th St., Philadelphia, Pa.
SCHANK, George E., (Associate 1926), 155 16th St., Buffalo, N. Y.
SCHANZE, A. G., (Associate 1925), Service and Sales Engr., (for mail), Hanson V. Parker, 50 Congress St., Boston, and 232 Warren St., Allston, Mass.
SCHEER, Frederick W., (1922), Htg. Contractor, (for mail), 131 Hartwell Rd., and 221 Commonwealth Ave., Buffalo, N. Y.
SCHEIBEL, Albert H., (1919), Asst. Engr., Stone & Webster, 147 Milk St., Boston, and (for mail), 92 Milton Ave., Hyde Park, Mass.
SCHEIDECKER, Daniel B., (Associate 1919), Salesman, (for mail), Bayley Mfg. Co., Rm. 1156, 38 S. Dearborn St., and 4626 N. Kilbourn Ave., Chicago, Ill.
SCHELLHAMMER, Alfred L., (1919), Schellhammer & Co., Warren, Ill.
SCHILDMILLER, George H., (1922), Asst. Mgr., (for mail), American Radiator Co., 400 Barlum Bldg., Detroit, and 908 Yorkshire Rd., Birmingham, Mich.
SCHLEY, Arthur A., (1920), Mgr., Htg. Dept., Schley & Nash Co., 709 Columbia Bk. Bldg., Pittsburgh, Pa.
SCHLOSS, Newton L., (1913), Imperial Brass Mfg. Co., 51 East 42nd St., New York, N. Y.
SCHMIDT, George C., (Junior 1912; 1914), Gen. Eastern Repr., McCann-Harrison Corp., 39 Cortlandt St., New York, and 67 Burns St., Forest Hills, L. I., N. Y.
SCHNEIDER, Charles, (1923), C. Schneider Co., 492 East 163rd St., New York, N. Y.
SCHNEIDER, Paul W., (1919), Pres., P. W. Schneider, Inc., 307 Lafayette St., and 2039 Genesee St., Utica, N. Y.
SCHOENIJAHN, Robert P., (1919), Consulting Engr., *(for mail),* Industrial Trust Bldg., Tenth and Shipley Sts., and 7 Crawford Circle, Wilmington, Del.
SCHOEPFLIN, Paul H., (1920), Pres., (for mail), Niagara Blower Co., 673 Ontario (Ontario at N. Y. C. Tracks), and 155 Fordham Drive, Buffalo, N. Y.
SCHOPP, Walter J., (1922), Partner, (for mail), General Engrg. & Construction Co., 419 Perry Bldg., and 1704 Ludlow St., Philadelphia, Pa.
SCHRADER, C. C.,* (Junior 1923; Associate 1925), Research Engr., (for mail), *Armstrong* Cork Co., Argo Laboratory, Gloucester, N. J., and 4842 N. Fifth St., Philadelphia, Pa.
SCHROTH, August H., (1911), Gen. Sales Mgr., Richmond Radiator Co., 1480 Broadway, New York, N. Y., and (for mail), 90 Oraton Parkway, E. Orange, N. J.
SCHULZ, Howard I., (Associate 1915), Local Mgr., Crane Co., 1217 W. Broad St., 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 266 Juneau Ave., Apt. 210, Milwaukee, Wis.
SCIPIO, Lynn A.,* (1921), Dean School of Engrg., Robert College, Constantinople, Turkey.
SCOLLAY, Ulysses G., (Charter Member), (Council 1894; Board of Managers 1895; Treas. 1904; 1911), Pres., J. A. Scollay, Inc., 76 Myrtle Ave., Brooklyn, N. Y.
SCOTT, A. P., (1924), Dennison Mfg. Co., 300 Howard St., Framingham, Mass.
SCOTT, Charles E., (1907), Pres. and Treas., (for mail), Vapor Engineering Co., 489 Fifth Ave., New York, N. Y., and West Ave., Darien, Conn.
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), Child & Scott Co., 108 Wooster St., New York, N. Y.
SEELIG, Alfred E., (1926), Pres. and Gen. Mgr., L. J. Wing Mfg. Co., 352 West 13th St., and (for mail), 310 Convent Ave., New York, N. Y.
SEELIG, Lester, (1925), Mech. Engr., Drying Systems, Inc., 1800 Foster Ave., and (for mail), 2630 N. Spaulding Ave., Chicago, Ill.
SEIDERS, John T., (1926), Mfgr's. Repr. and Engr., 5 W. State St., Columbus, O.
SEKIDO, Kunisuke, (1903), Nakano, Tokio Suburb, Japan.
SELIG, Ernest T., (1926), Member of Firm, (for *mail), Selig & Wilson 707 Telegraph* Bldg., 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, Kans.
SELLMAN, Niles T., (1922), Engr. of Utilization, (for mail), Consolidated Gas Co., 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), 73 Coligni Ave., New Rochelle, N. Y.
SETZER, Walter C., (Junior 1922; Associate 1926), H. B. Smith Co., 17th and Arch Sts., Philadelphia, and (for mail), N.W. Cor. Gillham St. and Hasbrook Ave., 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), 1822 Ludlow St., Philadelphia, and Warren Ave., Berwyn, Pa.
SHANKLIN, John R., (1899), Pres. and Gen. Mgr., (for mail), West Virginia Htg. & Plumbing Co., 233 Hale St., and 1507 Quarrier St., Charleston, W. Va.
SHAW, Clinton E., (1921), Instr., (for mail), Northeast High School, Eighth and Lehigh Ave., and 6412 North 11th St., Philadelphia, Pa.
SHAW, Edgar, (1923), Pres., Lynch & Woodward, Inc., 202 Harrison Ave., 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, and Boston Athletic Assn., Boston, Mass.
SHAY, Russell A., (1924), Htg. Engr., 108 Linwood St., Brooklyn, N. Y.
SHEA, John R., (1925), Asst. Supt. of Development, (for mail), Western Elec. Co., Inc., Hawthorne Sta., Chicago, and 319 N. Forest Ave., River Forest, Ill.
SHEA, M. B., (1921), Mgr., (for mail), American Radiator Co., 417 S. Tenth St., *and 3616 Lincoln* Blvd., Omaha, Nebr.
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.
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, 119 Harbord St., and 479 Dovercourt Rd., Toronto, Ont., Can.
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.
SHINOHARA, Shiro, (1924), Takata & Co., Marunouchi, and (for mail), 51 Iga Machi, Yotsuyaku, 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), Partner, Harry E. Shriner & Son, 116 W. High St., and 1240 Southern Blvd., Elkhart, Ind.
SHROCK, John H., (1924), Vice-Pres., (for mail), New York Blower Co., and Bellevue Apts., LaPorte, Ind.
SHUELL, Frank W., (Associate 1921), Pres. and Gen. Mgr., (for mail), Ever Hot Heater Co., 5241 Wesson Ave., and 360 E. Boston Blvd., Detroit, Mich.
SHULTZ, Earle, (Associate 1919), Vice-Pres., (for mail), Illinois Maintenance Co., Rm. 1136, Edison Bldg., and 1310 Birchwood Ave., Chicago, Ill.
SIEGEL, John F., (Associate 1915), Mgr., (for mail), Fuel Oil Burner Engrg. Co., 101 Park Ave., New York, and 220 Sheridan Ave., Mt. Vernon, N. Y.
SIEGEL, Leo, (*Junior 1924; Associate 1925*), Mech. Engr., Board of Education, Htg. and Vtg. Division, Flatbush and Concord Sts., and (for mail), 1507 Avenue U, Brooklyn, N. Y.
SIMONSEN, Lawrence A., (1920), Estimator and Engr., E. J. Claffey Co., 10 W. Illinois St., and (for mail), 6419 Vernon Ave., Chicago, Ill.
SIMPSON, William A., (1925), Mech. Engr., Johnson & Morris, 538 West 23rd St., and (for mail), 600 West 169th St., New York, N. Y.
SIMPSON, William K., (1919), Secy., (for mail), Hoffman Specialty Co., 193 Grand St., and 61 Fiske St., Waterbury, Conn.
SKAGERBERG, R., (Junior 1921; 1924), Dept. Mgr., Drying Systems, Inc., 1800 Foster Ave., Chicago, Ill.
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., Ft. Worth, Tex.
SLADE, Arthur J., (Associate 1925), Director 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, Pa.
SMALL, John D., (1910), Consulting Engr., (for mail), 127 N. Dearborn St., Chicago, and 411 Maple Ave., Wilmette, Ill.
SMALLMAN, Edwin W., (1920), Htg. and Vtg. Engr., Monks & Johnson, 99 Chauncy St., 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, Leslie L., (1919), Mech. Engr., (for mail), Smith, Hinchman & Grylls, 800 Marquette Bldg., and 1931 Delaware 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, Patrick J., (1923), W. J. McGuire, Ltd., 91 Jarvis St., and (for mail), 98 Woodfrey St., Toronto, Ont., Can.
SMITH, Sidney S., (1926), Vice-Pres., (for mail), Andes Range & Furnace Corp., and 517 Castle St., Geneva, N. Y.
SMITH, Virgil A., (Junior 1923), Sales Engr., (for mail), C. A. Dunham Co., 1434 Franklin Ave., Tampa, Fla.
SMITH, Woodworth M., (Associate 1924), Pres., The Koppen-Smith Co., 2629 Olive St., St. Louis, Mo.
SNELL, Ernest, (1920), Htg. and Vtg. Engr., 3914 LeMay Ave., Detroit, Mich.
SNYDER, Jay W., (1917), *Member of Firm*, (for mail), McColl, Snyder & McLean, 2348 Penobscot Bldg., and 8987 Martindale Ave., Detroit, Mich.
SNYDER, Joseph S., (Associate 1925), Sales Engr., (for mail), American Radiator Co., 1807 Elmwood Ave., and 39 Granger Place, Buffalo, N. Y.
SODEMANN, Paul W., (Junior 1920; Associate 1925; 1926), Sales Engr., Fischer Htg. Co., 367-369 Adams St., and (for mail), 1307 Worthington Place, Memphis, Tenn.
SODEMANN, William C., (1919), Vice-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.
SOMMER, Louis J., Jr., (1922), Sole Owner, 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., Aerofin Corp., 750 Frelinghuysen Ave., Newark, and 26 *Wootton* Rd., Essex Fells, N. J.
SOWERS, Paul E., (1922), Br. Mgr., Vapor Heating Co., 201 N. George St., and (for mail), P. O. Box 295, York, Pa.
SPECKMAN, Charles H., (1918), Rm. 572, Bourse Bldg., Philadelphia, Pa.
SPELLER, Frank N.,* (1908), Metallurgical Engr., (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), Treas., Harrison-Spielmann Co., Heating Contractors, 480 Milwaukee Ave., Chicago, and (for mail), 515 N. Prospect Ave., Park Ridge, Ill.
SPITZLEY, Ray L., (1920), Pres. and Gen. Mgr., (*for mail*), R. L. *Spitzley Heating* Co., 246 W. Larned St., and 1050 Yorkshire Rd., Grosse Pt., Detroit, Mich.
SPOFFORD, Harry H. R., (1923), Copper and Brass Research Assn., 25 Broadway, New York, N. Y.
SPOONER, Harold R., (1921), Engr. and Estimator, Atlas Heating Co., Inc., Jamacia, and (for mail), 33 Woodhull Ave., Hollis, L. I., N. Y.
SPRAGUE, Frank H., (1923), Sales Mgr., (for mail), Skidmore Corp., 1535 Dayton St., Chicago, and 1522 Forest Ave., Wilmette, Ill.
SPROULL, Howard E., (1920), District Mgr., American Blower Co., 1109 Keith Bldg., Cincinnati, O.

SPURGEON, Joseph H., (1924), 2403 First Natl. Bk. Bldg., 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., 4511 Delmar Blvd., and 308 N. Newstead, St., Louis Mo.
STACKHOUSE, Raymond M., (Associate 1908; 1919), Mgr., (for mail), American Radiator Corp., 509 Hannah Bldg., and Parkside Dwellings, Cleveland, O.
STAMMER, Edward L.,* (1919), Supt., Htg. and Vtg. Repairs, St. Louis Board of Education, Ninth and Locust Sts., and 4430 Tennessee Ave., St. Louis, Mo.
STANFORD, Leland E., (1921), Mgr., Forbs-Stanford Co., 756 Upson St., and (for mail), 120 E. Cuyahoga Falls Ave., Akron, O.
STANGER, Ralph B., (1920), Sales Engr., Robinson & Stanger, 917 Empire Bldg., 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. and Treas., (for mail), Stannard Power Equipment Co., 926 Monadnock Block, Chicago, and 1402 Elinor Place, Evanston, Ill.
STANWOOD, J. B., (1924), Vice-Pres. and Consulting Engr., The Stanwood Corp., and (for mail), 2415 Maplewood Ave., Cincinnati, O.
STAPLES, William H., (Associate 1924), Gillis & Geoghegan, 537 W. Broadway, and 137 West 96th St., New York, N. Y.
STARK, Edward A., (Associate 1914 1916), Br. Mgr., (for mail), U. S. Radiator Corp., 1248 First Ave., S., and 2338 Broadway, N., Seattle, Wash.
STARKS, Verne E., (1921), *Dist. Mgr., (for mail)*, Ilg Elec. Vtg. Co., 1314 Schofield Bldg., and 13502 Fourth Ave., Cleveland, O.
STEARNS, William F., (Associate 1925), (for mail), Stearns & Eaton, 100 Boylston St., Boston, and 2 Salisbury Rd., Winchester, Mass.
STEDMAN, Charles N., (1921), Dist. Sales Mgr., (for mail), C. N. Stedman Co., 610 Wrigley Bldg., and 6917 Crandon Ave., Apt. 2D, Chicago, Ill.
STEIM, Charles J., Jr., (1923), Mgr. Htg. Dept., (for mail), Samuel Sloan & Co., 67 Exchange St., and 94 Elm St., Rochester, N. Y.
STEINER, John G., (Associate 1922), (for mail), Utica Heater Co., 235 15th St., and 1368 Elizabeth St., Denver, Colo.
STEINHORST, Theodore F., (1919), Engr. and Estimator, (for mail), Emil Steinhorst & Sons, 1158 Mohawk St., and West Shore R. R., and *1664 Brinckerhoff* Ave., Utica, N. Y.
STEINKE, Bernard H., (Associate 1925), 17 Westewelt Place, W., Englewood, N. J.
STEINKE, G. B., (1924), Pres., (for mail), 103 Park Ave., New York, and 2730 Decatur Ave., Brooklyn, N. Y.
STEINMULLER, J. M., (1925), 245 Hunters Point Ave., Long Island City, N. Y.
STEPHENSON, Lewis A., (1917), Mgr., (for mail), Powers Regulator Co., 409 East 13th St., and 801 West 57th St., Kansas City, Mo.
STERN, H. Richard, (1923), (for mail), Johnson & Morris, 538 West 23rd St., and 225 West 86th St., New York, N. Y.
STERNBERG, I. C., (1926), Htg. and Vtg. Engr., Sprague & Slocum, 12 East 42nd St., and (for mail), 1271 Morris Ave., New York, N. Y.
STETSON, Lawrence R., (1913), (for mail), McMurrer Co., 303 Congress St., Boston, and 35 Bradfield Ave., Roslindale, Mass.
STEVENS, Frank H., (Associate 1924), Sales Engr., (for mail), Heggie Simplex Boiler Co., 622 First St., Detroit, Mich., and 4618 Kenmore Ave., Chicago, Ill.
STEVENS, Harry L., (Junior 1924), Member of Firm, (for mail), M. M. Stevens Co., 108 W. Sherman St., and 111 West 16th St., Hutchinson, Kans.
STEWART, C. W., (Associate 1918; 1919), 644 Riverside Drive, Apt. 2F, New York, N. Y.
STEWART, Earl A., (1922), Associate Prof. Agriculture Physics, Univ. of Minnesota, University Farm, St. Paul, Minn.
STILL, Fred R.,* (1904), (Presidential Member), (Pres. 1918; 2nd Vice-Pres. 1917; Council 1916-1919), Vice-Pres. and Secy., (for mail), American Blower Co., 50 Church St., New York, N. Y.
STITT, Eugene W., (1917), Sales Repr., Hoffman Specialty Co., 1535 Park Blvd., Dormont, and P. O. Box 45, S. Hills Branch, Pittsburgh, Pa.
STITT, Howard B., (Associate 1922), Htg. Engr., 506 West 29th St., Indianapolis, Ind.
STOCK, Edward L., (Associate 1918), Sales Mgr., (for mail), Niagara Radiator & Boiler Co., 11-17 Investment Bldg., Washington, D. C., and Bradley Hills, Bethesda, Md.
STOCKENBERG, Ruben, (1922), Sales Engr., (for mail), Johnson Service Co., 1355 W. Washington Blvd., and 1314 Columbia Ave., 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), Residence Mgr., Vtg. Engr., (for mail), Ilg Elec. Vtg. Co., 1024 Bessemer Bldg., Pittsburgh, and 843 River Rd., Avalon Borough, Pa.
STOLTENBERG, Thomas R., (1922), Sales Repr., Htg. and Vtg. Engr., (for mail), P. O. Box 1168, and Kenmark Hotel, Denver, Colo.
STONE, Eugene R., (1913), Pres., Stone-Underhill Htg. & Vtg. Co., 171 Harrison Ave., Boston, and 86 Sea Ave., Quincy, Mass.
STONE, George F., (1918), Engr. and Estimator, Wm. H. Walters & Sons, 1314 N. Carlisle St., and 4520 N. Carlisle St., Philadelphia, Pa.
STOREY, Thomas G., (Associate 1925), Sales Engr., The Toledo Edison Co., Jefferson and Superior, and (for mail), 1170 W. Woodruff Ave., Toledo, O.
STORM, Edwin S., (1916), Vice-Pres., (for mail), Hoffman Specialty Co., 130 N. Wells St., and 5220 Cornell Ave., Chicago, Ill.
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, Ralph C., (1919), Salesman, Pierce, Butler & Pierce Mfg. Corp., 31st and Oxford Sts., and (for mail), 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.
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.
SUTER, George, (1921), Htg. Contractor, (for mail), 210 E. Second St., and 1842 Barrett Ave., Sedalia, Mo.
SUTTERLEY, W. W., (1919), 503 North 52nd St., Philadelphia, Pa.
SWAIN, Wilbur A., (Associate 1926), Repr. and Engr., (for mail), Jenkins Bros., 80 White St., New York, N. Y., and 441 Elmora Ave., Elizabeth, N. J.
SWAN, Thomas J., (Junior 1925), Sales Engr., Hoffman Specialty Co., and 23 Athelwold St., Dorchester, Mass.

SWANEY, Carroll R., (Junior 1921), Salesman, (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., and 349 S. Weadock Ave., Saginaw, Mich.
SWEENEY, Sylvester H., (1915), Engr. and Contractor, S. H. Sweeney, Inc., 208 East 45th St., and 1916 Loring Place, New York, N. Y.
SZEKELY, Ernest, (1920), Consulting Engr., (for mail), 500 B. & R. T. Bldg., and 12537 Arliss Drive, Cleveland, O.

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TAGGART, Ralph C., (1912), Chief Engr., Dept. of Architect, 14 Lyon Ave., Menands, Albany, N. Y.
TAIT, George M., (1909), Htg., Vtg. and Sanitary Engr., 34 W. First St., Mansfield, O.
TALIAFERRO, Robert R., (1919), Carrier Engrg. Corp., (for mail), 1402 Land Title Bldg., and Beechwood Park, Philadelphia, Pa.
TALLMADGE, Webster, (1924), 50 Church St., New York, N. Y.
TANGEMAN, Bruno W., (Associate 1919), Mgr., (for mail), A. Y. McDonald Mfg. Co., 822 Third St., S., and 2716 Aldrich Ave., S., Minneapolis, Minn.
TANNEHILL, Louis W., (1925), 1420 S. Flower St., Los Angeles, Calif.
TATE, Sidney, (Associate 1926), Own Business, The Tate-Habelman Co., Htg. Contractors, 14113 Orinoco Ave., E. Cleveland, O.
TAVERNA, Frederick F., (Junior 1924), Htg. and Vtg. Engr., *Raisler Heating Co.*, 129 Amsterdam Ave., New York, N. Y., and 406 12th St., Union City, N. J.
TAYLOR, Milton A., (Associate 1925), Asst. to Pres., (for mail), Taylor-Forbes Co., Ltd., and 178 Queen St., Guelph, Ont., Can.
TAYLOR, R. Frederick, (1915), Consulting Engr., R. F. Taylor, 1020 Western Indemnity Bldg., and 5742 Richmond Ave., Dallas, Tex.
TAYLOR, Thomas S., (1921), Chief Research Physicist, Bakelite Corp., (for mail), 230 Grove St., Bloomfield, and 96 Westville Ave., Caldwell, N. J.
TEMPLIN, Charles L., (1921), Chief Engr., American Htg. & Vtg. Co., P. O. Box 876, and (for mail), 2223 Circle Drive, Raleigh, N. C.
TENKONOHY, Rudolph J., (1923), Sales Engr., (for mail), American Blower Co., 2136 Oliver Bldg., Pittsburgh, Pa., and 37 Stevens Ave., Highland Park, Mich.
TERRELL, Herbert A., (1915), Carrier Engrg. Corp., 39 Cortlandt St., New York, N. Y., and (for mail), 210 Manor Place, Cranford, N. J.
TERRY, Frank W., (Associate 1923), Sales Engr., Richmond Radiator Co., 1480 Broadway, New York, N. Y., and (for mail), 109 S. Grove St., E. Orange, N. J.
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), Asst. Sales Mgr. and Engr., (for mail), C. A. Dunham Co., 450 E. Ohio St., and 1907 Nebraska Ave., Chicago, Ill.
THOMAS, Bernard A., (Junior 1923), Sales Engr., Crane Co., Jacksonville, and (for mail), 109 W. Elm St., Winter Haven, Fla.
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 Ralph Ave., Toronto, Ont., Can.
THOMAS, R. H., (1920), Pres., (for mail), Economy Pumping Machine Co., 122-124 N. Curtis St., Chicago, and 426 Forest Ave., Oak Park, Ill.
THOMPSON, Hugh, (Associate 1925), Div. Mgr., Holland Furnace Co., 913 W. Eighth St., and 3415 Michigan Ave., Kansas City, Mo.
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, William P., Jr., (1915), (for mail), Thompson Bros., 520 Buttonwood St., and 1349 Colwyn St., Philadelphia, Pa.
THOMSEN, William T., (1919), Secy. and Treas., (for mail), International Engrg. & Supply Co., Suite 609, Tower Bldg., and 3408 Magnolia Ave., St. Louis, Mo.
THORNTON, Roger T., (1919), Sales Engr., (for mail), Buffalo Forge Co., 490 Broadway, and 46 Burbank Terrace, Buffalo, N. Y.
THRUSH, Homer A., (1918), Pres., (for mail), H. A. Thrush & Co., 21-23 E. River St., and 271 S. Broadway, Peru, Ind.
THUEM, Adolph E., (Junior 1922), Htg. and Vtg. Engr., (for mail), Board of Education, Bureau of Construction and Maintenance, Htg. and Vtg. Div., Flatbush Ave., Extension and Concord St., Brooklyn, and 444 East 87th St., New York, N. Y.
TIBBETS, John C., (1920), Htg. and Vtg. Engr., B. & O. R. R. Co., 1303 B. & O. Central Bldg., Baltimore, and (for mail), Ellicott City, Howard Co., Md.
TILDEN, Elwyn E., (1924), (for mail), Warren Webster & Co., 220 Devonshire St., Boston, and Holbrook, Mass.
TIMMERMAN, Manford M., (Junior 1921; 1925), Works Engrg. Dept., Westinghouse Elec. & Mfg. Co., E. Pittsburgh, and (for mail), 859 E. Hutchinson Ave., Swissvale, Pa.
TIMMIS, Pierce, (1920), Service Equipment Engr., (for mail), Dwight P. Robinson & Co., Inc., 125 East 46th St., New York, and Little Neck Rd., *Douglaston, L. I.*, N. Y.
TIMMIS, Walter S.,* (1911), (Presidential Member), (Pres. 1919; Council 1916; 1917; 1920; 1st Vice-Pres. 1918), Consulting Engr., (for mail), 315 Fifth Ave., New York, and Hillside and Homer Lee Aves., Jamaica, N. Y.
TIMMIS, William W., (Associate 1925), Sales Engr., Hoffman Specialty Co., 512 Fifth Ave., New York, and (for mail), 8828 181st St., Jamaica, L. I.
TINKER, William E., (Associate 1922), (for mail), Natl. Radiator Co., 121 N. Broad St., and 600 South 48th St., Philadelphia, Pa.
TISNOWER, William, (1923), Htg. Engr., 131 Livingston St., Brooklyn, N. Y.
TITZELL, J. Edgar, (1923), Vice-Pres., (for mail), Pacific Boiler Co., Inc., 101 Park Ave., and 27 West 95th St., New York, N. Y.
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.
TODD, James, (1922), Pres., (for mail), Sterling *Varnish Co., 528 Fulton Bldg., Pittsburgh, and* Sewickley, Pa.
TOENNIGES, George C., (1915), Sales Engr., 3417 N. Lincoln St., Chicago, Ill.
TOMLINSON, Malcolm C. W., (1924), Mech. Engr., Development Br., Western Elec. Co., Kearny, and (for mail), 191 Bellevue Ave., Upper Montclair, N. J.
TOOKER, Charles C., (1918), Htg. Engr., 113 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 1514 King St., LcCrosse, Wis.

TRIPP, Louis H., (1915), Chief Engr., U. S. Veterens Bureau, Arlington Bldg., and (for mail), 3721 Fulton St., N.W., Washington, D. C.
TRUITT, Joseph E., (Associate 1911; 1920), Pres., Autovent Fan & Blower Co., 736 W. Monroe St., Chicago, Ill.
TUCKER, Frank N., (1926), Field Engr., (for mail), Ilg Elec. Vtg. Co., Rm. 1108, 13 Park Row, and 9 West 28th St., New York, N. Y.
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., 220 Devonshire St., Boston, and Winchester, Mass.
TWEED, Carleton F., (1916), Chief Engr., Arlington Engrg. Corp., Rm. 812, 111 W. Jackson Blvd., and 338 N. Latrobe Ave., Chicago, Ill.
TWIST, Charles F., (1921), Secy. and Treas., (for mail), Ashwell, Twist & Cook, Inc., 305 Bell St., and 2310 Tenth Ave., N., Seattle, Wash.
TYLER, Frank T., (1922), Mgr., (for mail), Estimating Dept., Herman Nelson Corp., and 1615 Eighth Ave., Moline, Ill.

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UHLHORN, W. J., (1920), Sales Engr., Drying Sustems, Inc., 11 S. Desplaines St., Chicago, and (for mail), 733 S. Highland Ave., Oak Park, Ill.
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.
UPINGTON, George P., (1917), Sales Engr., Clarage Fan Co., 149 Broadway, New York, and 770 Greene Ave., Brooklyn, N. Y.

V

VALENTINE, Howard D.,* (1924), Direct Sales Engrs., The Peoples Gas Light & Coke Co., (for mail), 122 S. Michigan Ave., Chicago, and 245 Washington Blvd., Oak Park, Ill.
VAN ALEN, Walter T., (1924), Sales Engr., Htg. Dept., Standard Sanitary Mfg. Co., Pittsburgh, and (for mail), 1300 Darlington Rd., R. F. D. No. 1, Beacon Falls, Pa.
VANCE, Louis G., (1919), Owner, Vance & Vance, 1207 Garrett Bldg., and (for mail), 3601 Garrison Ave., Baltimore, Md.
VAN INWAGEN, Frank, (1916), Pres., Central Brake Shoe & Foundry Co., Railway Exch. Bldg., Chicago, and (for mail), 151 County Lene Rd., Hinsdale, Ill.
VAN NORDEN, Ernest M., (1923), The New York Edison Co., 130 East 15th St., New York, 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, 1903 Santa Fe 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., and 1563 Birchwood Ave., Chicago, Ill.
VIVARTTAS, Eugene A., (1910), Consulting Engr., 84 Fenimore 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), Sales Engr., The Stearns Roger Mfg. Co., 1720 California St., and 60 Albion St., Denver, Colo.
VOLK, Joseph H., (1923), Thos. E. Hoye Htg. Co., 1910 St. Paul Ave., Milwaukee, Wis.
VOORHEES, Guy A., (1922), Engr., Century Htg. Service Co., 32-36 W. Tenth St., and (for mail), 3451 Broadway, Indianapolis, Ind.
VOSE, Richard H., (1923), Johnson & Morris, 538 West 23rd St., New York, and (for mail), 18 Leland Ave., New Rochelle, N. Y.

W

WACHTER, John A., (1914), Pres., 723-25 W. Pratt St., Baltimore, and 112 Ailsa Ave., Hamilton, Baltimore, Md.
WADDINGTON, Bertram C., (1922), Engr., 805 World Herald Bldg., Omaha, Nebr.
WADDINGTON, Earle C., (1917), Sales Engr., W. B. Irwin, 911 Bankers Mortgage Bldg., Houston, Tex., and 3230 Tracy Ave., Kansas City, Mo.
WADLEY, Calvin Page, (1919), Pres., (for mail), Excelso Specialty Works, Inc., 65 Clyde Ave., and 60 Agassiz Place, Buffalo, N. Y.
WAGNER, A. M., (Associate 1921), Mgr., American Radiator Co., 692 Prior Ave., N., St. Paul, and 1626 West 25th St., Minneapolis, Ind.
WAGNER, John P., (Associate 1921), Concrete Products Mfg. Co., 705 Ralston Bldg., Miami, Fla.
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 Francis, (Junior 1925), Sales Engr., (for mail), Standard Heater Co., 433 Jackson Bldg., and 184 St. James Place, Buffalo, N. Y.
WALKER, James B., (1919), Treas., (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), Htg. and Vtg. Engr., McKenzie, Voorhees & Gmelin, 342 Madison Ave., Rm. 2022, New York, and 191-02 Central Ave., St. Albans, L. I., N. Y.
WALLACE, Albert, (1921), Htg. Engr., A. Wallace & Co., 402 Jacobson Bldg., and (for mail), 2971 Irving St., Denver, Colo.
WALLACE, George J., (1923), Principal Engr. and Contracting, 206 East 57th St., New York, and 27-36 Ericsson St., E. Elmhurst, L. I., N. Y.
WALLACE, John F., (1921), Secy. and Treas., Wallace Plumbing Co., 1238 California St., and 1320 S. Josephine St., Denver, Colo.
WALLICH, A. C., (1919), (for mail), Wallich Ice Machine Co., 517 E. Larned St., and 1211 E. Grand Blvd., Detroit, Mich.

WALSH, Arthur F., (Associate 1923), Htg. and Vtg. Contractor, A. F. Walsh, 7445 Exchange Ave., and 7536 S. Shore Drive, Chicago, Ill.

WALSH, Malcolm, (1924), Secy., (for mail), Walsh & Wertheim, 55 W. Houston St., New York, and 25 Sherman Ave., St. George, S. I., N. Y.

WALTERS, Arthur L., (Junior 1924; Associate 1925; 1926), Mgr. Furnace Dept., (for mail), The Buck's Stove & Range Co., 3550 N. Second St., St. Louis, and 7284 Richmond Place, Maplewood, Mo.

WALTERS, Victor, (Junior 1924), Inspector Ill. Central R. R. Co., Rm. 700, 109 East 12th St., and (for mail), 7049 St. Lawrence Ave., Chicago, Ill.

WALTERS, William T., (1917), Htg. and Vtg. Engr., Illinois Engrg. Co., 21st and Racine Ave., and 1422 East 69th St., Chicago, Ill.

WALTHER, Harry J., (1919), Harry B. Pancoast Co., 946-62 N. Front St., Philadelphia, Pa.

WALTHER, Owen N., (1919), Vice-Pres. and Chief Engr., (for mail), York Htg. & Vtg. Corp., 1502 Locust St., and 222 W. Rittenhouse Sq., Philadelphia, Pa.

WALTHER, Vernon H., (Junior 1925), Asst. in Mech. Dept., C. W. & Geo. L. Rapp, 190 N. State St., Rm. 1200, and (for mail), 6821 Osceola Ave., Edeon Park, Chicago, Ill.

WALTHERTHUM, John J., (Associate 1922), J. J. Waltherthum, 173 East 62nd St., New York, N. Y., and 834 Grand 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 Berwyn, Pa.

WARD, George C., (1925), Inspector Bureau Industrial Hygiene, N. Y. State Dept. Labor, 124 East 28th St., New York, and 86-87th St., Brooklyn, N. Y.

WARD, Oscar G., (1919), Dist. Mgr., (for mail), Johnson Service Co., 1230 California St., and 1515 E. Ninth Ave., Denver, Colo.

WARNKE, Fred E., (Associate 1921), Sales Engr., (for mail), 5005 Euclid Ave., Cleveland Heights, and 2641 Taylor Rd., Cleveland Heights, O.

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.

WASNER, W. M., (Associate 1924), Wasner & Reddig, 206 N. Sixth St., Reading, Pa.

WATKINS, James A., (1919), Sales Engr., American Blower Co., 140 S. Dearborn St., and (for mail), 7526 Kingston Ave., Chicago, Ill.

WATSON, John Howard, (1925), Chief Draftsman, Drying Systems, Inc., 1800 Foster Ave., and (for mail), 1909 Argyle St., Chicago, Ill.

WATSON, Raymond E., (1925), Designer, Muir & Brooke, Consulting Engrs., 163 W. Washington St., and (for mail), 5721 Magnolia Ave., Chicago, Ill.

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), Pres., (for mail), Willey & Calhoun Co., 46 Market St., and 45 Lincoln St., Woodfords, Portland, Me.

WEBER, Erwin L., (1921), Consulting Engr., (for mail), 723 Seaboard Bldg., and 3046 18th Ave., S., Seattle, Wash.

WEBER, G. A., (1922), Htg. Engr., McGinness, Smith, McGinness Co., 527 First Ave., Pittsburgh, and 618 Chautauqua St., Bellevue, 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. and Gen. Mgr., Warren Webster & Co., 17th and Federal Sts., and 626 Cooper St., Camden, N. J.

WEGMANN, Albert, (1918), Blower and Vtg. Engr., A. and W. Wegmann, 2813 Fletcher St., and (for mail), 2842 N. Bonsall St., Philadelphia, Pa.

WEIBERT, Charles J., (1921), (for mail), Weibert & Zibold Corp., 331 Vanderbilt Ave., and 89 Lewis Ave., Brooklyn, N. Y.

WEIDER, Frederick J., (1919), Vice-Pres. and Treas., (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.

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), The New York Blower Co., 2246 S. Halsted St., and 2638 N. Spaulding St., Chicago, Ill.

WEINSHANK, Theodore,* (1906), Board of Governors 1913), 3301 Schubert Ave., Chicago, Ill.

WEISS, Carl A., (Associate 1924), Partner, Supt., (for mail), Kornbrodt Kornice Ko., 1811-13-15 Troost Ave., and 4920 Walrond, Kansas City Mo.

WELAMB, Victor N., (1918), Contractor, (for mail), V. N. Welamb Co., 2313 Walnut St., and 1741 North 33rd St., Philadelphia, Pa.

WELSH, Harry S.,* (1906), Pres., The Boiler & Radiator Corp., 999 E. Main St., and 37 Flower City Park, Rochester, N. Y.

WELTER, Michael A., (Associate 1925), M. A. Welter & Co., (for mail), 2118 Lyndale Ave., S., and 4306 Garfield Ave., S., Minneapolis, Minn.

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.

WESCHLER, George A., (1923), Consulting Engr., and Prof. of Mech. Engrg., Catholic University of America, Transportation Bldg., and 2803 13th St., N.E., Washington, D. C.

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 R. R. No. 1, 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.

WHEELOCK, Harry C., (1919), 118 College St., Burlington, Vt.

WHELAN, William J., (1923), Harrigan Reid, 1705 First St., Detroit, Mich.

WHELLER, Harry S., (1916), Vice-Pres., L. J. Wing Mfg. Co., 352 West 13th St., New York, N. Y., and (for mail), 230 Stiles St., Elizabeth, N. J.

WHITAKER, Ernest C., (1925), Chief Engr., Buerkel & Co., Inc., 24 Union Park St., Boston, and (for mail), 35 Sherborn St., Arlington, Mass.

WHITBY, Stephen S., (Associate 1922), Treas., Culbert & Whitby Co., Inc., 2019 Rittenhouse St., Philadelphia, Pa., and (for mail), 208 Yale Rd., Audubon, N. J.

WHITE, Elwood S., (1921), Pres., Thermal Appliance Co., 342 Madison Ave., and 21 Washington Sq., New York, N. Y.

WHITE, Everett A., (1921), Head of Engrg. Dept., Crane Co., 30 South 16th St., and 4611 Delor St., St. Louis, Mo.

WHITE, Harold A., (Associate 1923), Mulley & White, 245 Greenpoint St., New York, and (for mail), 852 Knickerbocker Ave., Brooklyn, N. Y.

WHITE, M. G., Jr., (1925), 41 East 42nd St., New York, N. Y.

WHITE, Walker G., (Associate 1925), Westinghouse Elec. & Mfg. Co., 150 Broadway, New York, N. Y.

WHITLEY, James, (1919), Consulting Engr., Whiteley & Sanders, 3000 Grand River Ave., and 520 Navahoe Ave., Detroit, Mich.

WHITTEN, H. E., (1924), Pres. and Treas., (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., 1644 Lafayette Blvd., W., Detroit, Mich.

WHITTEMORE, Edward H.,* (1920), Engr., (for mail), Stone & Webster, Inc., 147 Milk St., Boston, and 96 Church St., W. Roxbury, Mass.

WHOMES, Harry, (1926), Works Mgr., (for mail), Bayley Mfg. Co., 732 Greenbush St., Milwaukee, and 529 11th Ave., Wauwatosa, Wis.

WHY, H. Berkeley, (1919), Constructing Engr., 312 Earlham Terrace, Germantown, Philadelphia, Pa.

WIDDICOMBE, R. A., (1903), 1120 Lake Shore Drive, Chicago, Ill.

WIEGNER, Henry B., (1919), Mgr., (for mail), Johnson Service Co., 31 Waltham St., Boston, and 77 Chester Rd., Belmont, Mass.

WIGGS, Gordon L., (Junior 1924), Mechanical Supply Co., Ltd., (for mail), 80-90 St. Paul St., and 189 Grande Allee, Quebec, P. Q., Can.

WIGLE, Bruce M., (Associate 1926), Owner, Bruce Wigle Plumbing & Htg. Co., 9117 Hamilton Ave., and 855 Clairmont Ave., Detroit, Mich.

WILCOX, Oscar H., (Associate 1917), Salesman, Ideal Furnace Co., 530 Jefferson Ave., and (for mail), 2545 Canton Ave., Detroit, Mich.

WILCOX, William, (1916), Dist. Engr., (for mail), Whitlock Coil Pipe Co., 6 Beacon St., Rm. 511, Boston, and 7 Biltmore St., Jamaica Place, Mass.

WILD, Walter H., (Associate 1921), Mfgrs. Agent, (for mail), 1212 Land Title Bldg., Philadelphia, and 122 Cynwyd Rd., Bala, Pa.

WILDE, Ray S. M., (1916), Consulting Engr., (for mail), 305 Huron 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), (2nd Vice-Pres. 1926; 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), Secy., National Warm Air Htg. & Vtg. Assn., 52 W. Gay St., and 51 Meadow Park Ave., R. R. No. 5, Columbus, O.

WILLIAMS, Jesse M., (Associate 1925), Pres., (for mail), Williams Radiator Co., 1864 W. Washington St., and 861 Harcourt Ave., Los Angeles, Calif.

WILLIAMS, J. Walter, (1915), Pres. and Treas., Forest City Plumbing Co., 332 E. State St., Ithaca, N. Y.

WILLIAMS, Oliver L., (Associate 1925), Br. Mgr., (for mail), Bryant Heater & Mfg. Co., 1305 E. End Trust Bldg., and 814 N. Negley Ave., Pittsburgh, Pa.

WILLIAMS, Robert Eubank, (1926), Consulting Engr., (for mail), 308 Home Insurance Bldg., and 2427 Broadway, Little Rock, Ark.

WILLIAMSON, Arthur H., (Associate 1915), Sales Mgr., (for mail), American Radiator Co. of Michigan, Broadway and Grand River Ave., Barlum Bldg., and 2272 Glynn Court, Detroit, Mich.

WILLIAMSON, Fred W., (1914), Consulting Engr., 324 New York Ave., Brooklyn, N. Y.

WILLIAMSON, George R., (1920), Sales Engr., The Mouat Vapor Heating Co., 1246 W. Fourth St., and 11016 St. Clair Ave., Cleveland, O.

WILLIS, Frederick H., (1921), Chief Engr., (for mail), W. N. Bowman Co., 612 Insurance Bldg., and 1110 Jackson St., Denver, Colo.

WILLIS, Ralph P., (1923), Sales Engr., (for mail), Peerless Unit Ventilation Co., Inc., 301 House Bldg., Pittsburgh, Pa., and 227 Audubon Ave., New York, N. Y.

WILMOT, Chas. S., (1919), Phoenixville, 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., 468 Pawling Ave., Troy, N. Y.

WILSON, Ernest J. F., (1923), Partner, Wiley & Wilson, Consulting Engrs., 801 Main St., and Oakwood Place, Lynchburg, Va.

WILSON, Eugene K., (1919), Wilson & Co., (for mail), 1017 Duke St., and 12 Lafayette Blvd., Norfolk, Va.

WILSON, F. A., (1910), 20945-110 Ave., Bellair, 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), Box 1903, 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., Most Supply Co., Fourth and Girard Ave., and (for mail), 5514 Paschall Ave., Philadelphia, Pa.

WILSON, William H., (Associate 1923), Wis. 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), Mech. Engr., (for mail), Walker & Eisen, Architect and Engr., 746 S. Spring St., and 5462 Carlm St., Los Angeles, Calif.

WINTERBOTTOM, John W., (1915), Vice-Pres. and Engr., Lock Box 2045, Sta. A., 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., Fifth and Sibley Sts., and 836 Juno St., St. Paul, Minn.

WINTERER, Raymond J., (1919), Mgr. Htg. Dept., Crane & Ordway Co., Fifth and Rosabel Sts., and (for mail), 197 S. Fairview St., St. Paul, Minn.

WISE, Frank W., (Associate 1918), Sales Engr., (for mail), General Boilers Co., 207 Davidson Bldg., and 2751 Charlotte St., 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, Narowetz Htg. & Vtg. Co., 1711-17 Maypole Ave., and (for mail), 3429 Medill Ave., Chicago, Ill.

WOHLMAN, Anton C., (Associate 1923), Pres., (for mail), Metal Equipment Co., 2033 West 106th St., and 1257 Beach Ave., Cleveland, O.

WOLF, J. C., (1923), Bayley Mfg. Co., 732 Greenbush St., Milwaukee, Wis.

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., and 25 McMaster Ave., Toronto, Ont., Can.
WOODLING, Miner D., (1926), Prop., (for mail), Miner D. Woodling Htg. & Vtg. Co., 428-30 Dwight Bldg., and 301 West 51st Terrace, Kansas City, Mo.
WOODRUFF, G. G., (Associate 1925), 3121 Main St., Kansas City, Mo.
WOOLLEY, Thos. R., (1916), Sales Engr., Woolley Engineering Co., 2457 Woodward Ave., and (for mail), 920 Seward 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. Elmer, (1924), Bowers Bros. & Co., 2015 Sansom St., Philadelphia, Pa.
WORM, Amdi, (Associate 1924), Factory Repr., Flaxlinum Insulating Co., 1425 Grand Ave., and (for mail), 2424 East 68th St., Kansas City, Mo.
WORTHING, E., (1923), Bayley Mfg. Co., 732 Greenbush St., and 56 Prospect St., Milwaukee, Wis.
WORTHINGTON, Thomas, (1922), Htg. Engr., Kewanee Boiler Co., 141 Albany Ave., Toronto, Ont., Can.
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., 207 Davidson 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, K., (1921), Mgr., (for mail), Johnson Service Co., 1113 Race St., and Westminster Apts., Lane Seminary, Cincinnati, O.
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. and Illumination, (for mail), Harvard School of Public Health, 55 Van Dyke St., Boston 17, Mass., and 213 Aspinwall Ave., Brookline, Mass.
YAMASAKI, Kanjiro, (Associate 1923), Htg. Engr., 927 Kashiwagi, Yodohash, Tokyo Suburb, Japan.
YARDLEY, Ralph W., (1920), Asst. Supt. of Construction, Ill. Penitentiary Comm., 717 Heggie Bldg., Joliet, and (for mail), 817 N. Dearborn St., Chicago, Ill.
YATES, Walter, (1902), Managing Dir., Matthews & Yates, Ltd., Swinton, Manchester, Eng.
YOUNG, Robert L., (1915), Mech. Engr., (for mail), Johns-Manville, Inc., 210 N. Broad St., and 522 North 55th St., Philadelphia, Pa.

Z

ZECK, Alex., (1904), Pres., Alex Zeck & Son Co., Morgantown, W. Va.
ZIEL, Herbert E., (1924), Albert Kahn, 1000 Marquette Bldg., Detroit, Mich.
ZIRHUT, George A., (Associate 1922), Onarga Plumbing & Htg. Co., P. O. Box 33, Onarga, Ill.
ZOKELT, C. G., (1921), (for mail), Northwest Engrg. Co., 414 Central Bldg., and 2355 16th Ave., S., Seattle, Wash.
ZOPATA, Edward L., (Associate 1924), Chief Mech. Draftsman, University of Michigan, 1310 Granger Ave., Ann Arbor, Mich.
ZUEHLKE, Rudolph, (1923), (for mail), Zuehlke-Stoehr Htg. Co., 1701 Clybourn St., Milwaukee, and 579 15th Ave., Wauwatosa, Wis.

Summary of Membership

(Corrected to July 1, 1926)

UNITED STATES

Alabama	5	Montana	4
Arkansas	1	Nebraska	8
California	25	New Jersey	75
Colorado	30	New York	381
Connecticut	22	North Carolina	6
Delaware	5	Ohio	88
District of Columbia	11	Oklahoma	4
Florida	6	Oregon	1
Georgia	15	Pennsylvania	286
Illinois	249	Rhode Island	8
Indiana	30	Tennessee	8
Iowa	14	Texas	10
Kansas	11	Utah	2
Kentucky	3	Vermont	4
Maine	4	Virginia	19
Maryland	20	Washington	20
Massachusetts	111	West Virginia	5
Michigan	109	Wisconsin	48
Minnesota	50	Wyoming	1
Mississippi	2		1811
Missouri	110		

FOREIGN COUNTRIES

Canada	70	New Zealand	1
China	9	Norway	1
Denmark	2	Russia	1
England	18	Sweden	1
France	3	Switzerland	1
Germany	1	Turkey	1
Ireland	1		116
Japan	5		
Mexico	1	Total Membership	1927

SUMMARY OF MEMBERSHIP BY GRADES

Honorary Members	1
Presidential Members	19
Members	1454
Associate Members	342
Junior Members	111
	1927

LIST OF MEMBERS

Arranged Geographically

UNITED STATES

ALABAMA

Birmingham—
Boisclair, H. C.
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Kaysing, H. C.
Keiser, W.
Kinealy, J. H.
Klein, W. A.
Lane, A. M.
Langenberg, E. B.
Legier, E. W.
Meara, J. J.
Messmer, G. E.
Milward, R. K.
Moon, L. W.
Niestrath, W. H.
Pickett, C. A.
Quentin, E. H.
Robertson, J. M.
Rosebrough, R. M.
Rossman, V. D.
Russell, W. L. A.
Sachleben, E. H.
Schulze, B. H.
Smith, W. M.
Sodemann, W. C.
Stack, M. F.
Stammer, E. L.
Thomsen, W. T.
Walters, A. L.
White, E. A.

Sedalia—
Suter, G.

MONTANA

Billings—
Cohagen, C. C.
Tooker, C. C.

Bozeman—
Powers, F. I.

Helena—
Bain, J. G.

NEBRASKA

Hastings—
Gedney, K. H.

Lincoln—
Phelps, G. H.

Omaha—
Davidson, H. MacD.
Hayes, P. M.
McCulley, D. E.
Shea, M. B.
Waddington, B. C.

Scottsbluff—
Davis, O. E.

NEW JERSEY

Arlington—
Krueger, W. E.

Atlantic City—
Nesbitt, A. J.
Nesbitt, J. J.
Strouse, S. B.

Audubon—
Whitby, S. S.

Beverly—
Mann, C. P.

Bloomfield—
Bartlett, C. D.
Hochuli, H. W.
Taylor, T. S.

Bogota—
Heebner, W. M.

Camden—
Eveleth, C. F
Kappel, G. W. A.
Strandwitz, W. J.
Webster, E. K.
Webster, W.

Cranford—
Terrell, H. A.

East Orange—
Crone, T. E.
Merkel, F. P.
Schroth, A. H.
Terry, F. W.
Turno, W. G. W.

Elizabeth—
Cornwall, G. T.
Pearce, C. E.
Wheller, H. S.

Englewood—
Steinke, B. H.

Essex Fells—
Stacey, A. E., Jr.

Gloucester—
Schrader, C. C.

Haddonfield—
Dobbs, C. E.

Hasbrouck Heights—
Goodwin, S. L.

Hilton—
Heiles, F. C.

Jersey City—
Butler, P. D.
Calahan, J. J.
Jones, H. L.
Reichwald, C. W.
Ritchie, W.

Jobstown—
Allinson, O. H.

Kearney—
Vogelbach, O.

Lyndhurst—
Ehrlich, M. W.
Knapp, A. F.

Maplewood—
Cadmus, R.
Smith, M. S.

Merchantville—
Binder, C. G.

Montclair—
Chapman, F. T.

Newark—
Bailey, J. H.
Bentz, H.
Carrier, W. H.
Janet, H. L.
Kieb, A. A.
Lewis, L. L.
Lindeman, H.
Lyle, J. I.
Noble, M.
Paget, B. K.
Soule, L. C.
West, P.

Passaic—
Boeker, C. H.
Hankin, R.
Morris, C. R.

Paterson—
Pryor, F. L.

Plainfield—
MacDougall, B. W.
Tobin, G. J.

Ridgefield—
Davis, A. C.

Riverton—
Brunt, T. B.

Short Hills—
Fouilhoux, J. A.

South Orange—
Baird, F. X.

Trenton—
Black, J. J. A.
Piper, A.
Piper, E. R. W.
Russell, W. E.

Union City—
Darton, A. W.
Taverna, F. F.

Upper Montclair—
Tomlinson, M. C. M.

West New York—
Maupai, R. G.
Ricker, J. J.

NEW YORK

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Hynes, L. P.
Murray, T. F.
Naden, L. J.
Ryan, H. J.
Taggart, R. G.

Bronxville—
Barr, G. W.

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Atwater, L. W.
Bampton, C. M.
Bender, C. P.
Blest, F. S.
Bondy, W. S.
Chadeayne, Geo. D.
Crutchley, E., Jr.
Dwyer, T. F.
Eells, H. B.
Ely, F. E.
Emery, W. D.
Gardner, B. F.
Gornston, M. H.
Grotz, A. B.
Hanley, J. H., Jr.
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Kiewitz, C.
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McCann, F. G.
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Musaus, J., Jr.
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Siegel, L.
Thuem, A. E.
Tisnower, W.
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Buffalo—
Ahlff, A. L.
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Case, E. W.
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Chittenden, F. J.
Criqui, A. A.
Danforth, N. L.
Davis, J.
Dempsey, H. P.
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Drake, G. H.
Dyer, O. K.
Eggleston, L. W.
Evans, C. A.
Farnham, R.
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Flink, C. H.
Frank, G. W.
Frank, O. E.
Frankel, G.
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Gauvin, L. G.
Gibbs, H. E.
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Howell, F. B.
Hutzel, H. F.
Jackson, M. S.
Kamman, A. R.
Kingsley, E. A.
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Madison, R. D.
Monin, E. H.
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Padginton, G.
Quigley, W. J.
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Riley, D. H.
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Walker, G. F.
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Wendt, H. W.
Yager, J. J.

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Sawade, C. A.

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Davenport, E. A.
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Ellison, J. H.

Geneva—
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Robinson, A. G.

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Longwell, H. E.

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Hinkle, E. C.

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Ertman, B. R.

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Bastedo, A. E.
Kittle, F. C.

Ithaca—
Sawdon, W. M.
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Gaylor, W. S.

Middletown—
Sanborn, S. H.

Millbrook—
Pizie, S. G.

Morton—
Stangland, B. F.

Mt. Vernon—
Donnelly, W. C.
Hunt, R. B.
Obert, C. W.

New Rochelle—
Vose, R. H.

New York City—
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Addams, H.
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Angus, R. A.
Armagnac, A. S.
Bachler, L. J.
Barwick, T.
Baum, A. L.
Beatty, D. J.
Beebe, F. E. W.
Bennitt, G. E.
Berman, L. K.
Binder, I.
Birch, H. A.
Bishop, C. R.
Blackmore, J. J.
Bloom, W.
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(L. I. City)
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Chase, J. M.
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(Richmond Hill, L. I.)
Cosgrove, W. M.
Cullen, H. J.
(Jamaica, L. I.)
Currier, C. H.
Dailey, J. A.
Dailey, J. F.
Darts, J. A.
Davis, P. L.
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Dill, H. O.
Dillon, H. R.
Doherty, J. A.
Donnelly, J. A.
Donnelly, R.
Donoghue, J. J.
Dornheim, G. A.
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(L. I. City)
Duff, K.
Durand, W. L.
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Easterbrooks, C. C.
Edelston, S. H.
Emerson, R. R.
Engle, A.
Engle, H. J.
Evans, W. A.
Faulkner, D. H.
Fay, F. C.
Febrey, E. J.
Feldman, A. M.
Fiedler, H. W.
Fleisher, W. L.
Fletcher, S. W.
Forgee, F. A.
Friedman, A.
Glore, E. F.
Goldberg, H. M.
Goldschmidt, O. E.
Gombers, H. B.
Goodnow, W. F.
Grill, G. E.
Hanson, H. A.
Heap, W. E.
(W. New Brighton)
Heatherton, J. M.
Hedges, H. B.
Hoffman, C. S.

Hoffman, G. D.
Hook, M. G.
Hubert, J. W.
Hunter, H. R.
Hunter, W. S.
Hyman, W. M.
Innis, H. R.
Ireland, T. H.
(Rockville Center, L. I.)
Issertell, H. G.
Jacobus, Dr. D. S.
Jalien, J. J.
Johnson, E. B.
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Johnston, W. H.
Junkers, H.
Kahn, H. P.
Keasbey, A. P.
Keenan, P. F.
Kellogg, T. M.
Kiewitz, A. A.
(L. I. City)
Kimball, D. D.
Kirk, L. G.
Klauss, L. J.
(Farmingdale, L. I.)
Knowles, A. F.
Koithan, W. S.
Lawrence, C. E.
LeBeau, J. F.
LeCompte, W. G.
London, I.
Lucke, C. E.
Lyle, E. T.
McKiever, W. H.
McMahon, W. W.
McMillan, L. B.
Macon, W. W.
Maier, G. M.
Marshall, H. H.
Martin, G. W.
Matthiessen, H. G. F.
Medway, F. J.
Meyer, H. C., Jr.
Miller, C. A.
Miller, E. A.
Miller, R. B.
Munder, J. F., Jr.
Munier, L. L.
Murphy, J. R.
Murphy, W. A.
Nicol, N. C.
Norton, F. W.
Oaks, O. O.
O'Donnell, T. J.
Offner, A. J.
Ohmes, A. K.
Olvany, W. J.
Oswald, W. L.
Parkhill, D.
Parter, S. C.
Patorno, S. A. S.
Paulding, L. G.
Peacock, J. K.
Petersen, G.
Pfeiffer, B. J.
Pfuhler, J. L.
(W. New Brighton, S. I.)
Pieron, A.
Pinder, P. H.
Place, C. R.
Pryor, R. W., Jr.
Purinton, D. J.
Quirk, C. H.
Raisler, L.
Raisler, S.
Ralston, L. T. M.
Reed, J. F.
Reynolds, T. W.
Riblet, W. H.
Richardson, D. R.
Riley, C. L.
Ritchie, E. J.
Ritter, A.
Rodman, R. W.
Ross, J. O.
Russell, W. A.
Samuels, S.
Schloss, N. L.
Schmidt, G. G.
Schneider, C.
Scott, C. E.
Scott, E. A.
Scott, G. M.
Seelig, A. E.
Sellman, N. T.
Senior, R. L.
Siegel, J. F.
Simpson, W. A.
Spofford, H. H. R.
Spooner, H. R.
(Hollis, L. I.)
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.
Tazelaar, P.
Timmis, P.
Timmis, W. S.
Timmis, W. W.
(Jamaica, L. I.)
Titzell, J. E.
Van Norden, E. M.
Vogt, J. H.
Walker, W. K.
Wallace, G. J.
Walsh, M.
Waltherthum, J. J.
Ward, G. E.
Watters, P. J.
(Port Richmond, S. I.)
White, E. S.
White, M. G.
White, W. G.
Wilson, F. A.
(Bellair, L. I.)
Wolff, R. A.
Wolfsfeld, C. F.
(Bayside, L. I.)
Wright, C. L.

N. Tonawanda—
Benedict, E. R.
Kline, W. J.
Slade, A. J.

Ogdensburg—
Skelly, J. F.

Port Chester—
Donovan, J. E.
Pratt, E. D.

Poughkeepsie—
Doherty, J. J.
Hawley, E. F.

Rochester—
Archer, F. S.
Aronwits, W.
Axeman, J. E.
Coe, I. B.
Coe, R. T.
Devendorf, W. F.
DeWolf, R. D.
Dobson, G. G.
Roebuck, W., Jr.
Steim, C. J., Jr.
Weider, F. J.
Welsh, H. S.
Wilder, E. L.
Wiley, C. S.

Saranac Lake—
Miller, P.

Scarsdale—
Janes, A.

Schenectady—
Baxter, R. A.
Harbison, E. J.
Vogel, A.

Syracuse—
Acheson, A. R.
Bradley, R. H.
Dennis, C. K.

Troy—
Brown, S. J.
Wilson, C. H.

Utica—
Brandeles, H. J.
Cantwell, W. T.
DeRosa, A.
Hamjy, P. W.
Hughes, W. C.
Norris, E.
Norris, J. K.
Phegley, F. G.
Schneider, P. W.
Steinhorst, T. F.

West Point—
Bryant, P. J.

White Plains—
Callahan, T. H.

Yonkers—
Brabbee, Dr. C.
Greason, D. R.
Kelly, J. G.
Rainger, W. F.

NORTH CAROLINA

Charlotte—
Christian, C. W.
Hackney, H.

Greensboro—
MacKenzie, B.

Raleigh—
Templin, C. L.

Weldon—
Chappell, T. A.

Winston-Salem—
Bahnson, F. F.

OHIO

Akron—
Humphrey, D. E.
Stanford, L. E.
Thatcher, G. S.

Cincinnati—
Allen, L. E.
Blomfeldt, A. A.
Bostain, J. C.
Doyle, W. J.
Green, W. C.
Grier, W.
Kiefer, C. J.
Kitchell, H. N.
Sproull, H. E.
Stanwood, J. B.
Wright, K.

Cleveland—
Adrianse, P. R.
Anderson, E. L.
Bailey, E. P.
Beyer, J. E.
Bray, D. S.
Bridges, F. G.
Brueggeman, A. R.
Clark, H. J.
Clark, W. C. M.
Colby, C. W.
Daugherty, F. M.
Davis, R. G.
Deex, C. J.
Empkey, G. J.
Farley, J. W.
Gottwald, C.
Graham, W. D.
Greene, W. C.
Harrison, B. S.
Harrison, J. M.
Hautz, E. H.
Kinner, J. E.
Kissick, J. J.
Klie, W.
Leonhard, F.
Matzen, H. B.
Mayer, R. S.
Mouat, T. G.
Nobis, H. M.
Osmon, T. R.
Quay, D. M.
Rather, M. F.
Rudio, H. N.
Stackhouse, R. M.
Starks, V. E.
Szekely, E.
Tate, S.
Van Sickle, W. B.
Warnke, F. E.
Weager, T. A.
Williamson, G. R.
Wohlman, A. C.

Cleveland Heights—
Heinle, E. L.
Neitzel, C. W.

Columbus—
Babbitt, E. C.
Babbitt, E. F.
Brown, A. I.
Fleming, R. A.
Mackensen, W. H.
Richards, F. A.
Wheeler, O. J.
Williams, A. W.

Dayton—
Brusman, H. M.
Gibbons, M. J., Jr.
Haas, W.
Hoersting, F. J.

Lakewood—
Kammerer, W. C.
Maurer, E. D.

Lorain—
Butler, T. F.
Lane, E. K.

Mansfield—
Tait, G. M.

Painesville—
Hobbs, J. C.

Pataskala—
Erickson, H. A.

Ravenna—
Franzheim, G. W.

Toledo—
Baker, H. C.
Bryce, S. D.
Gibbs, F. C.
Holmes, J.
Rogers, A. C.
Storey, T. G.

Warren—
Allen, L. E.
Lyman, W. I.
Moulder, A. W.

Youngstown—
Choffin, C. C.

OKLAHOMA

Oklahoma City—
Dolan, R. G.
Loeffler, F. X.
Rae, T. W.

Tulsa—
Jones, E.

OREGON

La Grande—
Anderson, S. A., Jr.

PENNSYLVANIA

Alleghany County—
Blackmore, G. C.

Allentown—
Buel, H. G.
Edwards, J. E.
Hersh, E. E.
Hersh, G. W.
Korn, C. B.

Ardmore—
Haynes, C. V.

Beacon Falls—
Van Alen, W. T.

Bradford—
Goodloe, A. M.
Green, C. E.

Bridgeport—
Longenecker, H. J.

Chambersburg—
Kottcamp, H. A.
Mehaffey, W. C.

Chester—
Boyd, W. R.

Cannonsburg—
Edwards, C. H.

Drexel Hill—Del. Co.
Jones, L. T.
Miller, A. A.

Erie—
Gannon, J. E.

Germantown—
Huckel, F., Jr.
Reeves, C. G.

Glenside—
Davis, B. H.

Harrisburg—
Eicher, H. C.
Filson, F. E.
Geiger, I. H.
Koehler, G. T.
Kressly, M. E.
Selig, E. T.

Indiana—
Lumsden, E. R.

Johnstown—
Rinkenberger, G.

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Grossman, H. M.
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Huzzard, E. C.
Vaux, F. J.

McKeesport—
Eckles, R. A.
Dugan, T. M.

New Castle—
McElroy, G. S.

Norristown—
Frost, R. V.
Gormly, J.
Gormly, P.

Oil City—
Heagerty, W. H.

Philadelphia—
Adams, B.
Anderson, C. A.
Arnold, R. S.
Bachler, H. C.
Bateman, W. H., Jr.
Beahm, R. B., 2nd
Black, E. N.
Black, H. G.
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.
Cadzow, W. S.
Carstens, E.
Cassell, J. D.
Cavileer, J. V.
Clarkson, R. C., Jr.
Cooper, T. W.
Culbert, W. G.
Dambly, A. E.
Dome, W. R.
Doud, M. P.
Driggs, L. L.
Duemler, F. C.
Dunlap, W. G.
Eagan, G. A.
Eagan, W. H.
Eastwood, H. F.
Eckardt, C. A. T.
Edgar, A. C.
Eggly, H. J., Jr.
Feige, H. W.
Feltwell, R. H.
Fest, L. T.
Fitz, J. C.
Fleming, T. C.
Francis, I. H.
Francis, W. C.
Galligan, A. B.
Galligan, J. H.
Gant, H. P.
Gibson, J. H.
Gilbert, M. F.
Giles, E. H.
Gillett, M. C.
Glassey, J. W.
Gomersall, W. H.
Gretzinger, F.
Grumbein, I. F.
Hackett, C. P.
Hackett, H. B.
Hellerman, H. H.
Hess, H. L.
Hetherington, E. T.
Hibbs, F. C.
Hoben, R. J.
Hoft, P. J.
Holloway, R. B.
Homann, F. A.
Hopkin, W. E.
Hucker, J. H.
Hunt, Phil M.
Hurley, J. C.
Hutchison, J. E.
Ickeringill, J.
Iddles, A.
Jellett, S. A.
John, B. F.
Jones, I. R.
Jones, R. E.
Kauffman, R.
Kauffmann, F. F.
Kellogg, H. D.
Kerney, T. F.
Kipe, J. M.
Kline, G. W., Jr.
Kriebel, A. E.
Levin, J.
Lewis, G. C.
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.
McGowan, T. F.
MacDade, A. H.
Mappett, A. S.
Matson, T.
Mellon, J. T. J.
Mensing, F. D.
Mervine, T. R.
Meyer, R. C.
Miller, W. C.
Meyers, J.
Minnich, H. S.
Monday, C. E.
Moody, L. E.
Morgan, R. C.
Mott, A. C., Jr.
Murphy, E. T.
Murphy, W. R.
Myers, G. W. F.
Nelson, F., Jr.
Nunan, J. F.
Nusbaum, L.
O'Connell, E. D.
Ogelsby, W. P.
Paine, L. G.
Patterson, D. F.
Pease, H. H.
Pennell, S. H.
Perkins, F. C.
Phillips, F. T.
Plewes, S. E.
Reuss, E. H., Jr.
Rice, W. W.
Roberts, H. L.
Rothrock, J. T.
Rugart, K.
Sabin, E. R.
Sanbern, E. N.
Sanville, C. P.
Scanlon, J. J.
Schopp, W. J.
Setzer, W. C.
Sewell, J. M.
Shaw, C. E.
Sheffler, M.
Sommer, L. J., Jr.
Speckman, C. H.
Stone, G. F.
Strong, R. C.
Sutterley, W. W.
Taliaferro, R. R.
Thompson, J.
Thompson, W. P.
Tinker, W. E.
Walther, H. J.
Walther, O. N.
Wandless, F. W.
Wegmann, A.
Welamb, V. N.
Why, H. B.
Wild, W. H.
Wilson, B. W.
Wilson, J. J.
Woolston, A. H.
Woolston, C. E.
Young, R. L.

Phoenixville—
Wilmot, C. S.

Pittsburgh—
Anderson, F. P.
Arthur, H. W.
Aston, J.
Bowman, H. A.
Brauer, R.
Bushnell, C. D.
Chester, T.
Clark, F. C.
Clark, W. H.
Dibble, S. E.
Digby, H. E.
Downes, H. H.
Easter, T. J.
Edwards, P. A.
English, A. T.
Evans, E. C.
Firsching, F. J.
Gunther, F. A.
Hanson, E. W.
Heilman, R. H.
Hitner, F. M.
Hook, C. H.
Houghten, F. C.
Ingels, M.
Jones, A. M.
King, T.
Langdon, J. D.
McCormick, E. T.
McGinness, J. E.
McGuigan, L. A.
McKenzie, P. C.
McIntosh, F. C.
McMurray, J.
Maginn, P. F.
Mansfield, F. A.
Moore, H. L.

Morgan, J. S.
Morrow, C. F.
Nicholls, P.
O'Neill, P.
Phillips, L.
Rederer, B. S.
Richards, S. F.
Schley, A. A.
Speller, F. N.
Stanger, R. B.
Stitt, E. W.
Stokes, R. E.
Tenkonohy, R. J.
Todd, J.
Waldron, C. W.
Walker, J. B.
Weber, G. A.
Wheeler, C. W.
Williams, O. E.
Willis, R. P.

Reading—
Luck, A. W.
Nicley, J. E.
Reese, H. L.
Wasner, W. M.

Ridley Park—
Bartlett, C. E.

Roxborough—
Blankin, M. F.

Scranton—
Gilboy, J. P.
Saville, T. H.

Sewickley—
Black, G. E.

Shamokin—
Gortner, J. W.

Swarthmore—
Clarke, H. W.

Swissvale—
Timmerman, M. M.

Tamaqua—
Hadesty, A. L., Jr.

Upper Darby, P. O.—
Hoisington, N. P.
Pisel, J. W.

Warren—
Schellhammer, A. L.

Washington—
McVehil, E. W.

West Chester—
Palmer, G. J.

Wilkinsburg—
Rasmussen, E.

Williamsport—
Chambers, W. E.
Gaulin, R. P.
McLain, R. D.
Pfeiffer, J. F.

Willow Grove—
Houpt, G. A.
Slight, I.

Wissahickon—
Peterman, R. M.

Wormleysburg—
Miller, T. G.

York—
Lindemuth, N. R.
Sowers, P. E.

RHODE ISLAND

Providence—
Coleman, J. B.
Dunlevy, T. R.
Gibbs, E. W.
Hartwell, J. C.
Husband, E. W.
Poole, E. F.

Pawtucket—
Martin, J. F.

Washington—
Wilson, H. A.

TENNESSEE

Chattanooga—
Russell, H. C.

Knoxville—
Reeder, F. C.

Memphis—
Allen, W. H.
Brewster, D. R.
Gray, W. E.
Gray, W. E.
Sodemann, P.

Nashville—
Brown, F.
Hailey, S. H.

TEXAS

Austin—
Giesecke, F. E.

Dallas—
Taylor, R. F.
Van Zandt, J. H.

Fort Worth—
Burnett, E. S.
Skinner, H. W.

Galveston—
Helphingstein, O.

Houston—
Barnes, A. F.

San Angelo—
Hogue, C. T.

San Antonio—
Diver, M. L.
Ebert, W. A.

UTAH

Salt Lake City—
Coogan, J.
Cooper, A. W.

VERMONT

Burlington—
Austin, F. L.
Raine, J. J.
Wheelock, H. C.

N. Ferrisburg—
Breckenridge, L. P.

VIRGINIA

Lynchburg—
Cleland, James 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.
Childress, W. L.
Connolly, Chas. I.
Johnston, J. A.
Koch, H. O.
Schulz, H. I.

Roanoke—
Wash, W. P.

Staunton—
Moffett, W. S.
Moran, F. N.

WASHINGTON

Bremerton—
Bysom, L. L.

Seattle—
Ayers, A. E.
Carsten, W. H.
Cox, W. W.
DeLong, F. B.
Dudley, W. L.
Eastwood, Prof. E. O.
Eckart, C. H.
Godfrey, F. H.
Lavan, P. J.
Mallis, W.
Moore, J. C.
O'Connell, P. M.
Ruddell, W. H.
Stark, E. A.
Twist, C. F.
Weber, E. G. L.
Zokelt, C. G.

Spokane—
DeLong, H. B.
Nelson, R. L.

WEST VIRGINIA

Charleston—
Matthews, J. K.
Meyers, S. H.
Shanklin, J. R.

Morgentown—
Zeck, A.

Wheeling—
Hare, E. S.

WISCONSIN

Eau Claire—
Grosvold, F. E.

Fond Du Lac—
Ahern, T. L.

Fort Akinson—
Shodron, J. G.

Green Bay—
Kingsbury, J. W.

La Crosse—
Anderegg, R. H.
Johnson, T. R.
Trane, R. N.

Madison—
Larson, G. L.

Milwaukee—
Berghoefer, V. A.
Bowers, A. F.
Cook, H. 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.
Meadows, F. H.
Miller, C. W.
Miller, H. M.
Mueller, P. E.
Noll, W. F.
Olson, R. G.
Ostrander, L. F.
Page, H. W.
Pflugradt, A. G.
Randolph, C. H.
Rice, C. J.
Schwab, H. E.
Ver Halen, E. T.
Volk, J. H.
Weimer, F. G.
Whomes, H.
Wilson, W. H.
Wolf, J. C.
Worthing, E.
Zuehlke, R.

Superior—
Jarvis, G. E.

Wausau—
Bassler, E. M.
Cornwell, F. E.
Sargent, L. F.

Wauwatosa—
Dannies, F. R.

West Allis—
Erickson, M. E.

Wisconsin Rapids—
Eron, L. J.

WYOMING

Cheyenne—
Meyring, A. S.

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CANADA

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Clarke, S. S.
Latham, G.
Walker, A.

Victoria, B. C.—
Sheret, A.

Galt, Ont.—
Evans, J.
McCaffrey, H. G.

Guelpl—
Taylor, M. A.

Halifax, N. S.—
Eagar, R. F.
Gray, G. A.
Harrington, C.

Islington, Ont.—
Wilson, G. T.

Kingston, Ont.—
Arkley, L. M.
Druce, J. J.

Montreal, Que.—
Fry, J. D.
Friedman, F. J.
Grahame, D. F.
Hamlet, F. A.
Hamlet, T. F.
Higgins, T. J.
Kastello, A.
Osborne, G. H.
Peterson, E. A.
Wiggs, G. L.

Quebec—
Dube, W.

Sault Ste.—
Wilson, W. S.

Toronto, Ont.—
Addy, E.
Angus, H. H.
Baldwin, W. H.
Birrell, A. L.
Blackhall, W. R.
Church, H. J.
Clifton, W. F.
Cole, G. E.
Dickey, A. J.
Doughty, C. J.
Duncan, J. M.
Flett, H. R.
Gaby, F. A.
Henion, H. D.
Laidlaw, E. J.
Leitch, A. S.
McHenry, R. W. M.
McMichael, P.
MacKenzie, J. J.
Mansell, P. C.
Millar, R. J.
Moore, H. S.
O'Neill, J. W.
Paterson, J. S.
Paterson, W. B.
Peterkin, S. M.
Playfair, G. A.
Purdy, A. K.
Quesnel, N. W.
Shears, M. W.
Sheffield, E. B.
Sheppard, W. G.
Smith, P. J.
Thomas, M. F.
Wood, J. S.
Worthington, T.

Vancouver, B. C.—
Givin, A. W.
Johnston, R. E.
Leek, W.
McCreery, H. J.

Westmount—
Bladon, J. B.

Windsor, Ont.—
Bowden, F.

Winnipeg—
Fulton, W. J.
Kirk, C. D.
Mackie, J.

CHINA

South Manchuria—
Katsumoto, E.

Shanghai—
Alt, H. L.
Cooper, T. R.
Doughty, C. J.
Hauss, C. F.
Merritt, C. J.

Tientsin—
Baker, H. W. H.
Barre, L. S.

DENMARK

Copenhagen—
Reck, A. B.

Smedegade, Slagelse—
Ulrich, K. F.

ENGLAND

Hull—
Hill, E. G. T.

Leeds—
Jennins, H. H.

Leicester—
Nesbit, D. M.

Liverpool—
Honiball, C. R.

London—
Barker, A. H.
Craig, F. B.
Groom, S. L.
Herring, E.
Nobbs, W. W.
Robinson, S. W.
Russell, J. N.

Manchester—
Chadwick, J. B.
Row, O. M.
Yates, W.

Southport—
Atkinson, R. E.

Sunderland—
Vaux, N.

Trowbridge—
Haden, G. N.
Haden, W. N.

York—
Fryer, F. G.

FRANCE

Paris—
Beaurrienne, A.
Downe, H. S.
Modiano, R.

GERMANY

Stuttgart—
Klein, A. R.

IRELAND

Cork—
Barry, P. I.

JAPAN

Tokyo—
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.

SWEDEN

Stockholm—
Theorell, H. G. T.

SWITZERLAND

Winterthur—
Meier, K.

TURKEY

Constantinople—
Scipio, L. A.

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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
Edwatd 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.*	C. B. J. Snyder
R. C. Carpenter	D. M. Nesbit
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.*	A. B. Franklin
T. J. Waters	James Mackay
R. C. Carpenter	B. F. Stangland
Frank K. Chew	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.*	Edmund F. Capron
Wm. G. Snow	Frank K. Chew
R. E. Atkinson	A. B. Franklin
R. C. Carpenter	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
B. S. Harrison	James Mackay
John R. Allen	B. F. Stangland
R. C. Carpenter	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.*	Judson A. Goodrich
Samuel R. Lewis	John F. Hale
Geo. W. Barr	James Mackay
R. C. Carpenter	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.*	James H. Davis
A. B. Franklin	Jas. D. Hoffman
John T. Bradley	August Kehm
R. C. Carpenter	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
Frank T. Chapman	Frank G. McCann
Homer Addams	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.*	E. Vernon Hill
Arthur K. Ohmes	Dwight D. Kimball
Homer Addams	Henry C. Meyer, Jr.
Charles R. Bishop	Fred R. Still
Frank I. Cooper	Walter S. Timmis
Milton W. Franklin	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.*	Charles A. Fuller
Fred R. Still	Harry M. Hart
Homer Addams	E. Vernon Hill
Davis S. Boyden	James M. Stannard
Bert C. Davis	Walter S. Timmis
Milton W. Franklin	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-President.....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.*	Jay R. McColl
Homer Addams	George B. Nichols
Jos. A. Cutler	Robt. W. Pryor, Jr.
Wm. H. Driscoll	W. S. Timmis
A. C. Edgar	Perry West
Alfred Kellogg	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.*	E. S. Hallett
Homer Addams	E. Vernon Hill
Jos. A. Cutler	Alfred Kellogg
Samuel E. Dibble	E. E. McNair
Wm. H. Driscoll	Perry West
H. P. Gant	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.*	L. A. Harding
Homer Addams	E. E. McNair
Jos. A. Cutler	H. J. Meyer
Samuel E. Dibble	C. L. Riley
Wm. H. Driscoll	Perry West
E. S. Hallett	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.*	E. S. Hallett
W. H. Carrier	Alfred Kellogg
J. A. Cutler	Thornton Lewis
S. E. Dibble	J. R. McNair
Wm. H. Driscoll	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.*	W. E. Gillham
F. Paul Anderson	L. A. Harding
W. H. Carrier	Alfred Kellogg
J. A. Cutler	Thornton Lewis
William H. Driscoll	Perry West
H. P. Gant	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.*	W. T. Jones
Homer Addams	Thornton Lewis
F. Paul Anderson	J. H. Walker
W. H. Carrier	Perry West
J. A. Cutler	A. C. Willard
W. E. Gillham	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.*	C. V. Haynes
W. H. Carrier	W. T. Jones
J. A. Cutler	E. B. Langenberg
S. E. Dibble	Thornton Lewis
W. E. Gillham	J. F. McIntire

A. C. Willard