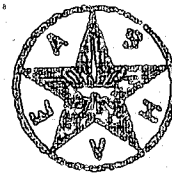


HEATING AND VENTILATING GUIDE



1922

AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS
1922



1

SC-ASHVE-001

ST. LOUIS
PUBLIC
LIBRARY



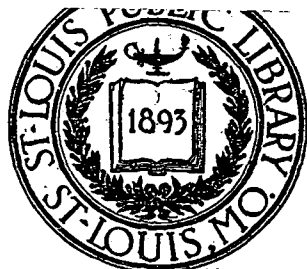
American Society of Heating and St
Ventilating Engineers
Heating ventilating air
conditioning guide.
VOL 1 1922

628.8
AMERICAN

21718 75600

24

50



No. 887714

This book shall not be taken from the library

**AMERICAN SOCIETY OF
HEATING AND VENTILATING
ENGINEERS
GUIDE
1922**

CONTAINING REFERENCE DATA USEFUL IN THE DESIGN AND CONSTRUCTION
OF HEATING AND VENTILATING INSTALLATIONS, COMPILED FROM
THE SOCIETY'S TRANSACTIONS, THE INVESTIGATIONS OF
ITS RESEARCH LABORATORY, AND THE PRACTICE
OF ITS MEMBERS,

TOGETHER WITH A

**CATALOGUE AND REFERENCE
DATA SECTION**

COMPRISING ESSENTIAL AND RELIABLE FACTS, DATA AND APPLICATIONS
OF MANUFACTURERS' EQUIPMENT UNIFORMLY PRESENTED,
AN

ENGINEERING AND EQUIPMENT SECTION

COMPOSED OF ILLUSTRATIONS AND TECHNICAL DATA ON ACTUAL
BUILDINGS, EXEMPLIFYING THE PRESENT STATE OF THE
ART OF HEATING AND VENTILATING
AND

AN INDEX TO MODERN EQUIPMENT

**A DIRECTORY OF
CONSULTING ENGINEERS**

VOLUME ONE

June, 1922

887714

Published Annually by

**AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS
29 West 39th Street, New York**

Price \$3.00 per copy. This issue 7,000 copies

Copyright, 1922, by
American Society of Heating & Ventilating Engineers

Ref. 628.8

PREFACE

IN issuing this, the First Annual Edition of THE GUIDE, a distinctly new service is rendered by the Society, not only to its membership but to the heating and ventilating industry at large.

The purpose of this new addition to the Society's publications is to provide the engineer, the architect and the contractor alike, with a useful and reliable reference data book relating to the art of heating and ventilating. A wide range of data within the scope of the field is presented and every effort has been made to present the material in a practical and usable manner.

In addition, the Catalog Data Section provides a means whereby manufacturers may inform the users of heating and ventilating equipment of the most modern and advanced equipment available, suggesting the proper applications of such equipment. The data presented in the Catalog Data Section forms not only a compend of reliable information, but a collection of *related* data which will permit more intelligent selection and comparison of modern equipment.

The American Society of Heating and Ventilating Engineers, being an institution for the advancement of the arts and sciences connected with its field, publishes this volume to render a service to the industry and to form a cooperative basis for closer contact between the maker and user of equipment. Any funds which may accrue from the activity will be devoted to research, which will react to the mutual advantage of the entire profession, as well as the trade.

All Catalog Data presented have been carefully edited in an effort to eliminate exaggerated claims or statements. However, it must be borne in mind that publication of manufacturers' data does not imply the Society's endorsement or approval, and that the Society cannot assume responsibility for statements made in catalog data or in papers presented.

The data appearing in the General Data Section are based upon the most reliable information obtainable and represent the actual practice of the most prominent and successful engineers in the field. As rapidly as possible the Research Bureau will investigate these data and standardize them for the general use of the profession and the trade. The findings of the Research Bureau will be published in future editions of THE GUIDE and thus made, annually and continuously, available to the profession and the trade.

The Guide Publication Committee realizes that this, the first edition of THE GUIDE, is imperfect in many ways. It represents, however, the most

PREFACE—Continued

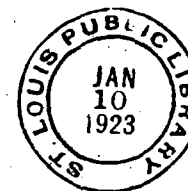
careful and thorough work which the time and circumstances permitted. We bespeak, for the following editions, the enthusiastic cooperation of both the profession and the trade at large to the end that THE GUIDE may become the standard reference work in our field, performing a needed and valuable service in the advancement of the art, both as to engineering and as to equipment.

This Committee has not fully realized its hopes with reference to any given Section in THE GUIDE, but it particularly regrets that it was unable in the short time and with the limited personnel available, to secure the understanding cooperation of every manufacturer represented in the Catalog Data Section. Therefore certain data, particularly with reference to boilers and heaters, do not conform with the desirable bases of rating. Wherever boiler or heater manufacturers do not definitely state that their ratings are in accordance with the A. S. H. & V. E. Code, and where the firing period upon which the rating is based is not stated, users of THE GUIDE should request this information directly from the advertiser before comparing the given ratings with the ratings of other manufacturers which accord with the recognized Code and are based upon stated firing periods of probably greater length than those not stated.

This Committee releases THE GUIDE, 1922, to the press, with the sincere hope that its users will find it a useful and worthy reference book, and that its advertisers will find it an effective medium for promoting the use of modern equipment.

Guide Publication Committee.

Society Standards,
Committee Reports
and
Technical Papers from the
Society's Transactions



SOCIETY STANDARDS AND COMMITTEE REPORTS

SOON after its organization the Society recognized the need for standardization of method and practice in its field in order that true comparisons might be made. As the need for a standard is made apparent a technical committee is organized, composed of the members who, due to their experience, are most capable to consider the subject, and a draft is formulated. Such drafts of codes or standards are then submitted to the Society at the time of its meetings and thoroughly discussed by the membership at large. When corrected and accepted by the membership, or, in certain instances, approved by the Research Bureau, the codes and standards are submitted to the Council of the Society and, when approved, become a Society Standard.

The Society, since its organization, has approved many reports of the Committees who were appointed to prepare Standards and Codes to indicate preferred practice, in the heating and ventilating art. Of these reports the Society's Research Laboratory has endorsed three, (1) Report of special Committee on Standards for Flanged Fittings and Flanges (Transactions, Vol. XVIII, p. 44); (2) Report of the Committee on the Use of the Pitot Tube (Transactions, Vol. XX, p. 210); (3) Report of the Committee on Code for Testing Low Pressure Heating Boilers, 1919 Revision (Transactions, Vol. XXV, p. 143), and in addition has accepted the Synthetic Air Chart, introduced by Dr. E. V. Hill, Past President of the Society, and approved at the Semi-Annual Meeting of the Society in 1920.

Abstracts of these Standards, Codes and Reports are here presented with such notes and comments as the Committee deemed desirable.—

THE GUIDE PUBLICATION COMMITTEE.

REPORT OF SPECIAL COMMITTEE ON STANDARDS FOR FLANGED FITTINGS AND FLANGES

At the recommendation of the Committee, the Society accepted the 1912 U. S. Standard Schedule of Standard Weight and Extra Heavy Flanged Fittings and Flanges (published in the Journal of the A. S. M. E.—pamphlet copies available). The report (Transactions, Vol. XVIII, p. 44) embraces the following subjects:

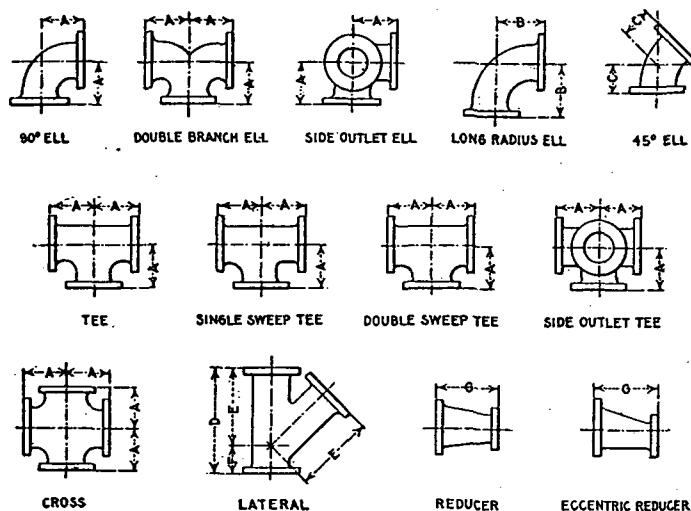


FIG. 1. STANDARD TYPES OF FLANGE FITTINGS DIMENSIONED IN
TABLES 1 AND 2

Bolt Circles
Flange Diameters
Flange Cross Sections
Bolt Diameters
125 lb. Working Pressure
250 lb. Working Pressure

Additional Sizes
Interchangeability
Cast-Iron Pipe Wall Thicknesses
Pipe Wall Stresses
Changes in Number of Bolts

Tables covering dimensions of fittings for 125 lb. and 250 lb. working pressures are quoted from the standard together with illustrations of the standard types of flange fittings dimensioned therein.

Size	1	1 1/4	1 1/2	2	2 1/2	3	3 1/2	4	4 1/2	5	6	7	8	9	10	12	14	15
Face to face	8	8 1/2	9	10	11	12	13	14	15	16	17	18	20	21	23	26	30	31 1/2
Center to face of long radius ell.	4	4 1/4	4 1/2	5	5 1/4	5 1/2	6	6 1/4	6 1/2	7	7 1/4	7 1/2	8	8 1/4	9	10 1/4	11 1/4	12 1/4
Center to face of 45-deg. ell.	2	2 1/4	2 1/2	3	3 1/4	3 1/2	4	4 1/4	4 1/2	5	5 1/4	5 1/2	6	6 1/4	7	8 1/4	9 1/4	10 1/4
Face to face, lateral	8 1/2	9 1/4	10 1/4	11 1/4	12 1/4	13 1/4	14 1/4	15 1/4	16 1/4	17 1/4	18 1/4	20 1/4	21 1/4	23 1/4	26 1/4	30 1/4	31 1/4	33 1/4
Center to face, lateral	4 1/4	4 3/4	5 1/4	6 1/4	7 1/4	8 1/4	9 1/4	10 1/4	11 1/4	12 1/4	13 1/4	15 1/4	16 1/4	18 1/4	21 1/4	24 1/4	27 1/4	29 1/4
Face to face, reducer	4 1/4	4 3/4	5 1/4	6 1/4	7 1/4	8 1/4	9 1/4	10 1/4	11 1/4	12 1/4	13 1/4	15 1/4	16 1/4	18 1/4	21 1/4	24 1/4	27 1/4	29 1/4
Thickness of flange	1 1/4	1 1/2	1 3/4	2	2 1/4	2 1/2	2 3/4	3	3 1/4	3 1/2	3 3/4	4	4 1/4	4 1/2	4 3/4	5 1/4	5 3/4	6 1/4
Diameter of bolt circle	4 1/4	4 3/4	5 1/4	6 1/4	7 1/4	8 1/4	9 1/4	10 1/4	11 1/4	12 1/4	13 1/4	15 1/4	16 1/4	18 1/4	21 1/4	24 1/4	27 1/4	29 1/4
Number of bolts	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
Diameter of bolts	3/4	3/4	3/4	3/4	3/4	3/4	3/4	3/4	3/4	3/4	3/4	3/4	3/4	3/4	3/4	3/4	3/4	3/4
Minimum metal thickness of body	1/4	1/4	1/4	1/4	1/4	1/4	1/4	1/4	1/4	1/4	1/4	1/4	1/4	1/4	1/4	1/4	1/4	1/4

Size	16	18	20	22	24	26	28	30	32	34	36	38	40	42	44	46	48
Face to face	33	36	39	41	45	48	52	55	58	61	65	68	71	74	78	81	84
Center to face of long radius ell.	16 1/2	18 1/4	20 1/4	22 1/4	24 1/4	26 1/4	28 1/4	30 1/4	32 1/4	34 1/4	36 1/4	38 1/4	40 1/4	42 1/4	44 1/4	46 1/4	48 1/4
Center to face of 45-deg. ell.	8 1/4	9 1/4	10 1/4	11 1/4	12 1/4	13 1/4	14 1/4	15 1/4	16 1/4	17 1/4	18 1/4	19 1/4	20 1/4	21 1/4	22 1/4	23 1/4	24 1/4
Face to face, lateral	42	45 1/4	49 1/4	53 1/4	57 1/4	61 1/4	65 1/4	69 1/4	73 1/4	77 1/4	81 1/4	85 1/4	89 1/4	93 1/4	97 1/4	101 1/4	105 1/4
Center to face, lateral	21 1/4	22 3/4	24 1/4	26 1/4	28 1/4	30 1/4	32 1/4	34 1/4	36 1/4	38 1/4	40 1/4	42 1/4	44 1/4	46 1/4	48 1/4	50 1/4	52 1/4
Face to face, reducer	21 1/4	22 3/4	24 1/4	26 1/4	28 1/4	30 1/4	32 1/4	34 1/4	36 1/4	38 1/4	40 1/4	42 1/4	44 1/4	46 1/4	48 1/4	50 1/4	52 1/4
Thickness of flange	2 1/4	2 1/4	2 1/4	2 1/4	2 1/4	2 1/4	2 1/4	2 1/4	2 1/4	2 1/4	2 1/4	2 1/4	2 1/4	2 1/4	2 1/4	2 1/4	2 1/4
Diameter of bolt circle	20 1/4	22 1/4	24 1/4	26 1/4	28 1/4	30 1/4	32 1/4	34 1/4	36 1/4	38 1/4	40 1/4	42 1/4	44 1/4	46 1/4	48 1/4	50 1/4	52 1/4
Number of bolts	20	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24
Diameter of bolts	1 1/4	1 1/4	1 1/4	1 1/4	1 1/4	1 1/4	1 1/4	1 1/4	1 1/4	1 1/4	1 1/4	1 1/4	1 1/4	1 1/4	1 1/4	1 1/4	1 1/4
Minimum metal thickness of body	1 1/4	1 1/4	1 1/4	1 1/4	1 1/4	1 1/4	1 1/4	1 1/4	1 1/4	1 1/4	1 1/4	1 1/4	1 1/4	1 1/4	1 1/4	1 1/4	1 1/4

Notes:—Figures given are for center to face and for face to face finished dimensions. Where necessary manufacturers will make suitable allowances in patterns before casting the 24 in. size at the present time. For wrench to be used on bolting for large sizes. Lateral holes with hexagonal nuts and washers should be used with a nut at each end and is satisfactory. Hexagonal nuts for pipe sizes 1 in. to 16 in. can be conveniently pulled up with wrenches of minimum design of heads. Hexagonal nuts for pipe sizes 18 in. to 48 in. can be conveniently pulled up with socket wrenches. Distance between inside edges of bolt holes and raised face to be 1/4 in. Flanges to be spot bored for nuts. Thickness of flanges given in table includes raised face. All extra heavy fittings and flanges to have a raised surface of 1/16 in. high inside of bolt holes for gaskets.

TABLE 1. AMERICAN STANDARD, 125 LB. WORKING PRESSURE PER SQUARE INCH, STANDARD FLANGE FITTINGS, STRAIGHT SIZES

Size	1	1 1/4	1 1/2	2	2 1/2	3	3 1/2	4	4 1/2	5	6	7	8	9	10	12	14	15
Face to face.....	7 3/4	8	9	10	11	12	13	14	15	16	17	18	19	20	22	24	28	29
Center to face.....	3 3/4	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Center to face of long radius ells.....	5 1/4	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
Center to face of 45-deg. ells.....	1 1/4	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Face to face laterals.....	7 1/4	8	9	10	11	12	13	14	15	16	17	18	19	20	22	24	28	29
Center to face.....	3 1/4	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Center to face reducer.....	1 1/4	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Face to face reducer.....	4 1/4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
Thickness of flange.....	3 1/4	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Diameter of bolt circle.....	3 1/4	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
No. of bolts.....	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
Diameter of bolts.....	3/4	7/8	1	1 1/8	1 1/4	1 1/2	1 3/4	2	2 1/4	2 1/2	2 3/4	3	3 1/4	3 1/2	3 3/4	4	4 1/4	4 1/2
Minimum metal thickness of body.....	1/4	1/4	1/4	1/4	1/4	1/4	1/4	1/4	1/4	1/4	1/4	1/4	1/4	1/4	1/4	1/4	1/4	1/4

Size	16	18	20	22	24	26	28	30	32	34	36	38	40	42	44	46	48
Face to face.....	30	33	36	40	44	48	52	56	60	64	68	72	76	80	84	88	92
Center to face.....	14	16	18	20	22	24	26	28	30	32	34	36	38	40	42	44	46
Center to face of long radius ells.....	24	26	28	31	34	36	39	41	44	46	49	51	54	56	59	61	64
Center to face of 45-deg. ells.....	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
Face to face laterals.....	30	33	36	40	44	48	52	56	60	64	68	72	76	80	84	88	92
Center to face.....	14	16	18	20	22	24	26	28	30	32	34	36	38	40	42	44	46
Center to face reducer.....	18	19	20	22	24	26	28	30	32	34	36	38	40	42	44	46	48
Thickness of flange.....	23 1/2	25	27 1/2	30	33	36	39	41	44	46	49	51	54	56	59	61	64
Diameter of bolt circle.....	21 1/2	23	25 1/2	28	31	34	36	39	41	44	46	49	51	54	56	59	61
Diameter of bolts.....	1 1/4	1 1/2	1 3/4	2	2 1/4	2 1/2	2 3/4	3	3 1/4	3 1/2	3 3/4	4	4 1/4	4 1/2	4 3/4	5	5 1/4
Minimum metal thickness of body.....	1	1 1/4	1 1/2	1 3/4	2	2 1/4	2 1/2	2 3/4	3	3 1/4	3 1/2	3 3/4	4	4 1/4	4 1/2	4 3/4	5

Notes.—Figures given are for center to face and for face to face finished dimensions. Where necessary manufacturers will make suitable allowances in place of the figures given. The 30-in. size at the present time. Box wrench to be used on bolting for large sizes. Square head bolts with hexagonal nuts are recommended. 1 1/4 in. diameter and larger stud with a nut at each end is satisfactory. Hexagonal nuts for pipe sizes 1 in. to 46 in. can be conveniently pulled up with open wrenches of minimum design of heads. Hexagonal nuts for pipe sizes 48 in. to 100 in. can be conveniently pulled up with socket wrenches. Flanges to be spot bored for nuts for sizes 32 in. to 100 in. inclusive.

TABLE 2. AMERICAN STANDARD, 250 LB. WORKING PRESSURE PER SQUARE INCH, EXTRA HEAVY FLANGE FITTINGS, STRAIGHT SIZES

REPORT OF COMMITTEE ON STANDARDIZATION OF THE USE OF THE PITOT TUBE

(Transactions, Vol. XX, p. 210)

The Committee rendered a careful report which included two tables and a list of references on the theory of the Pitot tube and the derivation of formulae. An extract from the report is given below.

"The reading should be taken at a cross section where the pipe is straight and the flow undisturbed. This should be preferably at least 10 diameters from the fan outlet, from an elbow, or from a change in cross section in the duct. The readings should be taken over a plane at right angles to, and the tube should be pointed in a direction parallel to, the direction of the air flow.

The most difficult reading to take accurately in a current of air is the static pressure. The approved form of static tip shown by diagram B, is the form recommended for fan-testing work. There should be eight or more clean holes 0.02 in. in diameter, an equal number on each side of a 1/4-in. tube 1/32 in. thick. The most approved form of Pitot tube combines the foregoing static tip with an impact tube as shown by diagram C, by means of which total, static, or velocity pressure may be read.

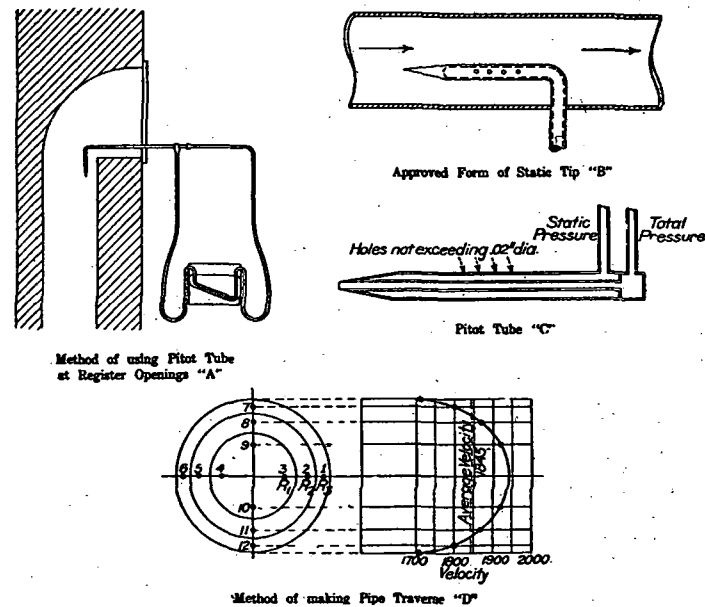


FIG. 1. STANDARD METHOD OF USING PITOT TUBE

In making a traverse of a rectangular duct, the cross sectional area may be divided into a number of smaller rectangles and a reading taken in the center of each small rectangle.

A round pipe should be divided into at least three concentric zones of equal area per foot in diameter and four readings taken on a circle drawn through the center of area of each zone or ring.

That is, readings should be taken across the horizontal and vertical axis of the pipe as shown on diagram D. The location of these points from the center is shown together with the accompanying table No. 1, which gives the distance from the center of the pipe to point of reading, expressed in per cent. of the pipe diameter.

To get exact results a small pipe should be divided into more zones than a pipe of larger diameter, as the ratio of frictional surface to cross sectional area is greater, hence the more static pressure in proportion to the impact pressure, which correspondingly reduces the velocity pressure.

The corresponding velocities for each of these readings should be determined and an average taken of all of these velocities in order to compute the air quantity. *Inasmuch as the velocity varies as the square root of the pressure, accurate results cannot be obtained by averaging the pressure readings and taking the corresponding velocity as the average.*

TABLE 1. PIPE TRAVERSE FOR PITOT TUBE READINGS

Distance from Center of Pipe to Point of Reading in Percent. of Pipe Diameter

No. of Equal Areas in Traverse	No. of Readings	1st R.	2nd R.	3rd R.	4th R.	5th R.	6th R.	7th R.	8th R.
3	12	20.4	35.3	45.5					
4	16	17.7	30.5	39.4	46.6				
5	20	15.5	27.2	35.3	41.7	47.4			
6	24	14.5	25.0	32.3	38.2	43.3	47.9		
7	28	13.4	23.1	29.9	35.3	40.1	44.3	48.2	
8	32	12.5	21.6	28.0	33.2	37.6	41.5	45.1	48.4

The velocity may be determined from the velocity pressure by use of the formula.

$$v = 1096.5 \sqrt{\frac{P}{W}}$$

v = velocity in ft. per min.

P = pressure in in. of water.

W = weight of air in lb. per cu. ft. under the existing conditions of temperature, barometer and humidity.

With dry air at 70 deg. and 29.92 in. barometer,

$W = 0.0749$ whence the formula becomes

$$v = 4005 \sqrt{P}$$

With saturated air at 70 deg. and 29.92 in. barometer,

$W = 0.0735$ and

$$v = 4046 \sqrt{P}$$

For dry air at any temperature and pressure.

$$W = \frac{0.0028862B}{1 + 0.0021758T}$$

For moist air:

$$W = \frac{0.0028862B - 0.001088e}{1 + 0.0021758T}$$

where B = height of barometer in inches of mercury.

T = temperature in deg. fahr.

e = vapor pressure.

(Source—W. H. Carrier.)

Where approximate results only are desired:

For circular pipe, multiply the velocity pressure taken at the center of the pipe by 0.81 or the velocity by 0.91.

For rectangular pipe, no definite factor can be given, which is even approximately correct, that will cover the varying proportions of width to height of the cross sectional area of rectangular ducts.

The Committee recommends the Pitot tube as a simple and convenient instrument for the measurement of air or gases, which, when used with the proper care and accuracy of reading, gives results with an error of less than 1½ per cent. with velocity pressure ranging from 0.1 in. upwards.

DIRECTIONS FOR FIELD TESTS WITH THE PITOT TUBE

For the information of those who are not familiar with the use of the Pitot Tube, the following explanation is appended by the Guide Publication Committee.

In determining the velocity and pressures of air in ducts by the use of a pitot tube, a hole must be punched in the duct preferably at least 10 diameters of the duct

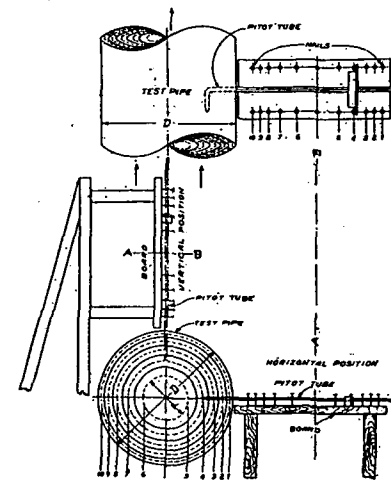


FIG. 2

from the fan inlet or outlet or from an elbow or change in cross section of the duct. For ordinary determinations, this hole should be made at the center of the top or bottom of the duct and made just large enough to admit the Pitot Tube. Where great accuracy is desired or where it is necessary to make readings close to the fan outlet or to elbows, both horizontal and vertical readings should be made.

In order to make readings at the points in the duct indicated in Table 1, in the above report, it will be found convenient to clamp the Pitot Tube in a block as indicated in Fig. 2 and construct a board with nails or pegs inserted so as to hold the tube at the desired points.

For measuring pressures exceeding 1 in., the ordinary manometer is sufficiently accurate. However, in ventilation systems, where the velocity pressure is usually below 1 in. the inclined manometer containing gasoline, usually colored for convenience in reading, will be found most convenient and accurate. Inclined manometers can be obtained with either a fixed inclination or constructed so that various inclina-

tions for different ranges of pressure may be obtained. The latter will be found more convenient and accurate for general field use as they are so constructed that they may be mounted on a tripod or on any vertical or horizontal support.

Having mounted the pitot tube and manometers as indicated in Fig. 3, it is usually the practice to connect them by means of rubber tubing, special care being taken to have air-tight connections. This can be tested by blowing into the tube and then closing the openings in the tube with the fingers and observing any drop in the manometer. If a noticeable drop occurs, it indicates loose connections.

When a static pressure above atmospheric exists in the duct, the manometers and pitot tube should be connected as shown in diagram for blowing tests. The upper manometer which is connected both to the dynamic and static tubes will record the difference or velocity pressure, while the lower manometer which is connected only to the dynamic tube, will record the dynamic pressure. Both of these readings will be positive. The static pressure can be obtained by subtracting the velocity pressure from the dynamic pressure.

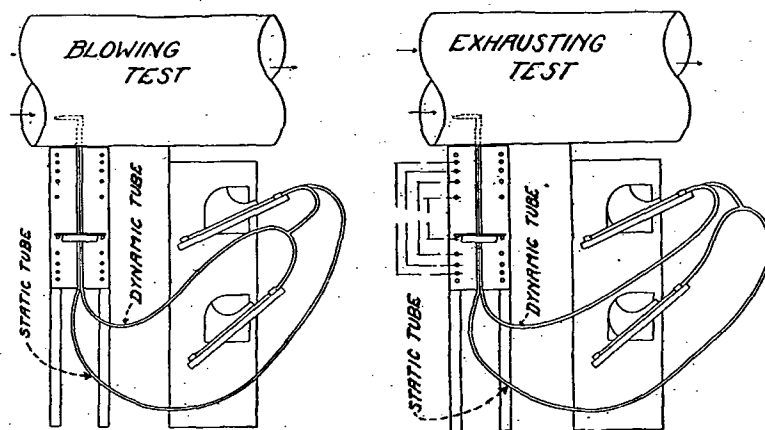


FIG. 3

In making a test where the static pressure within the duct is below that of the atmosphere, connect apparatus as shown for exhausting test in Fig. 3. The upper manometer will record the velocity pressure which will be positive, while the lower manometer will record static pressure which will be negative.

As stated in the above report, for accuracy the velocity corresponding to each reading should be calculated separately and then the velocities should be averaged. However, for field work, if the readings are taken at the positions shown in the centers of the rings or circles of equal area, there will be no appreciable error if the readings are averaged and the velocity computed on the mean.

Corrections must be made for the specific gravity of the gasoline and the inclination of the manometer.

Example—In a blowing test conducted as here outlined, using a manometer inclined 1 to 10 for the velocity reading, and using colored gasoline with a specific gravity of 0.74, a reading of one inch was observed. The air was practically dry at 120 deg. fahr., barometer at 30 in. The equivalent inches of water will be $1 \times 1/10 \times 0.74$ or 0.074 inches of water. The weight of the air will be

$$W = \frac{0.0028862 \times 30}{1 + 0.0021758 \times 120} = 0.0687$$

$$\text{then } v = 1096.5 \sqrt{\frac{0.074}{0.0687}}$$

$$v = 1140 \text{ ft. per minute.}$$

REPORT OF COMMITTEE ON STANDARD METHOD OF MEASURING THE VELOCITY OF AIR THROUGH WARM AIR REGISTERS WHEN THE ANEMOMETER IS USED

(Transactions of the A. S. H. V. E., Vol. XIX, p. 203)

The report in full is as follows:

1. The opening shall be divided into equal rectangular areas, no side of which shall be over 10 inches long, excepting where this would require more than ten readings, in which case the opening shall be divided into twelve equal areas.
2. Readings are to be taken in every case at the center of every area.
3. Readings are to be of one-half minute duration, the anemometer being held at the register base or in the plane of the opening.
4. Where the diffusers are used, the total area is to be computed on the basis of the periphery of the diffuser.
5. The average of the readings is to be considered as the average velocity at the opening. Where negative velocities are found, they are to be deducted in arriving at the average velocity.
6. In computing volume, the net area of opening is to be taken, the volume to be considered as the product of the average velocity and the net area of the opening.
7. If the anemometer is held two inches from the register face, no deduction shall be made for the area occupied by the register mesh.

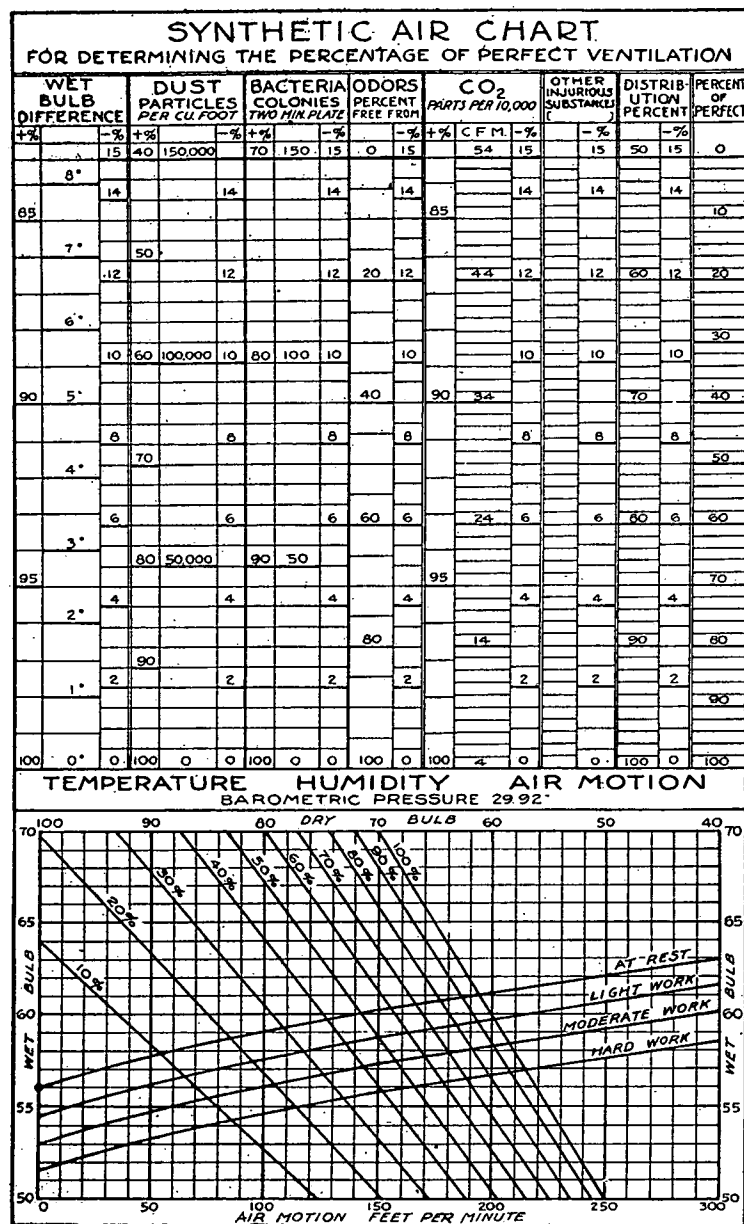
REPORT OF COMMITTEE ON TESTS ON TEMPERATURE CODE FOR TESTING HEATING SYSTEMS

(Transactions of A. S. H. V. E., Vol. XVI, p. 44.)

In this report, the Committee on Tests presented the following table, worked out from a formula incorporated in the 1903 report of the Committee on Standards. The table is for use only in case of direct radiation, steam or hot water, and should show the relative capacity of the radiation; although not necessarily showing the capacity of the boiler.

TABLE 2. INDOOR AND OUTDOOR TEMPERATURES SHOWING EQUIVALENT HEATING CAPACITY TO 70 DEG. INSIDE AND 0 DEG. OUTSIDE

		Temp. of Radiator, deg. fahr.									
Outside Temperatures		160	170	180	190	200	210	220	230	240	
		Room Temperatures Deg. Fahr.									
2	71.1	71.2	71.2	71.2	71.3	71.3	71.3	71.3	71.4	71.4	
4	72.2	72.3	72.4	72.5	72.6	72.7	72.7	72.7	72.8	72.8	
6	73.4	73.5	73.7	73.8	73.9	74.7	74.1	74.2	74.2	74.2	
8	74.5	74.7	74.9	75.	75.2	75.3	75.5	75.6	75.7	75.7	
10	75.6	75.9	76.1	76.3	76.5	76.7	76.8	77.	77.1	77.1	
12	76.7	77.	77.3	77.6	77.8	78.	78.2	78.3	78.5	78.5	
14	77.9	78.2	78.5	78.8	79.1	79.3	79.5	79.7	79.9	79.9	
16	79.	79.4	79.7	80.2	80.4	80.7	80.9	81.1	81.3	81.3	
18	80.1	80.5	81.	81.3	81.7	82.	82.3	82.5	82.7	82.7	
20	81.2	81.7	82.2	82.6	83.	83.3	83.6	83.9	84.1	84.1	
22	82.3	83.	83.4	83.9	84.3	84.7	85.	85.3	85.5	85.5	
24	83.5	84.1	84.6	85.1	85.6	86.	86.4	86.7	87.	87.	
26	84.6	85.3	85.9	86.4	86.9	87.3	87.7	88.1	88.4	88.4	
28	85.7	86.5	87.1	87.7	88.2	88.6	89.1	89.5	89.8	89.8	
30	86.9	87.6	88.3	89.	89.5	90.	90.4	90.9	91.2	91.2	
32	88.	88.8	89.5	90.2	90.8	91.4	91.8	92.2	92.6	92.6	
34	.....	90.	90.8	91.5	92.1	92.6	93.2	93.6	94.	94.	
36	.....	.....	92.	92.8	93.4	94.	94.5	95.	95.4	95.4	
38	.....	.....	.....	94.	94.7	95.4	95.9	96.4	96.9	96.9	
40	.....	.....	.....	.....	96.	96.6	97.2	97.8	98.3	98.3	
42	.....	.....	.....	.....	.....	98.	98.6	99.2	99.9	99.9	
44	.....	.....	.....	.....	.....	.....	100.	100.6	101.2	101.2	
46	.....	.....	.....	.....	.....	.....	.....	102.	102.6	102.6	
48	.....	.....	.....	.....	.....	.....	.....	.....	104.	104.	



MODUS OPERANDI OF THE SYNTHETIC AIR CHART

In view of the announcement that after three years of investigation of the question of a standard for measurement of ventilation, the Society had adopted the Synthetic Air Chart for the purpose of comparing the air conditions in any room with the ideal or standard conditions, the Research Bureau worked out the following description of its method of application. It was thought that the operation of the Synthetic Air Chart might not be found entirely clear without some explanation and the Research Bureau submitted the following brief statement for the benefit of those interested, together with illustrations of the apparatus necessary to make the measurements involved.

THE Synthetic Air Chart offers a means of determining the percentage of perfect ventilation by considering all the known factors that make up the air conditions in a room. These factors with their proper weights, experimentally determined, are represented by columns arranged vertically across the chart. The base of each column represents the ideal condition, or 100 per cent perfect. Bordering on either side of the main column are two narrow columns marked “- %” and “+ %.” The former denotes the penalization to be subtracted from the Percent of Perfect column, and the “+ %” denotes the condition considering only the one particular factor.

The various factors are divided into three groups which are separated by the double lines. *First*, Wet Bulb Difference which includes Temperature, Humidity, and Air Motion; *second*, Dust, Bacteria, and Odors; *third*, Carbon Dioxide. The latter, although not really a factor, since it is not considered injurious, serves as an index of the amount of air supplied and of the distribution in the room. In addition, columns providing for Other Injurious Substances and for Distribution are given. The upper limit of any of these groups represents the condition where life would cease to exist. Hence at this point the “- %” column would indicate 100 per cent penalization. (Since the upper ends of the columns represent conditions not obtained in practice they are not included on the chart.)

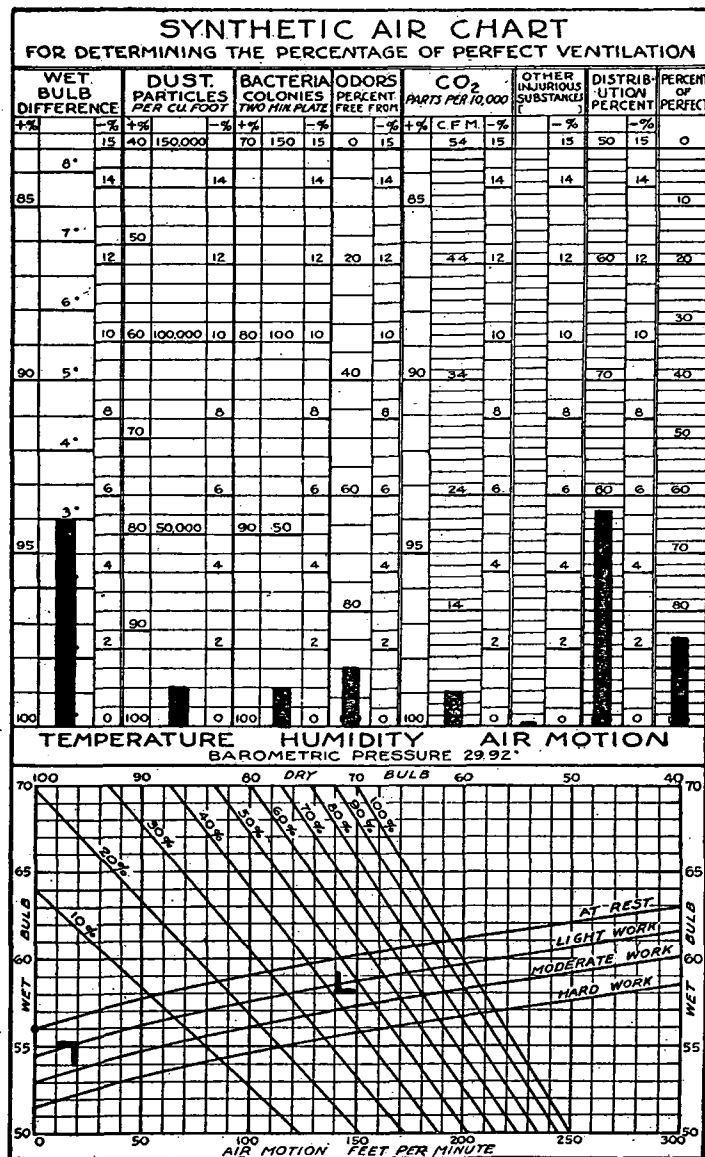


FIG. 1. ILLUSTRATION OF THE USE OF THE SYNTHETIC AIR CHART.

To illustrate the method of graduating the columns, consider the first which is headed Wet Bulb Difference. When at rest with no air motion, the ideal wet bulb temperature is 56 deg. The upper portion of the column represents the unlivable condition which is approximately 106 deg. with 100 per cent humidity or a wet bulb difference of 50 deg. from the ideal. Any variation from 56 deg. would therefore represent a definite percentage of variation from the ideal. The graduations in the other columns were constructed in like manner.

After the values of all the factors have been determined by test, the results are shown on the chart by a heavy vertical line ($\frac{1}{8}$ in. wide) and the height of the line will indicate the results obtained in the test. Penalizations for all the factors may then be read directly opposite the top of each line. All the “-%’s” are then totaled and the sum subtracted from 100 per cent to determine the Percent of Perfect ventilation for the room as a whole. This result is plotted

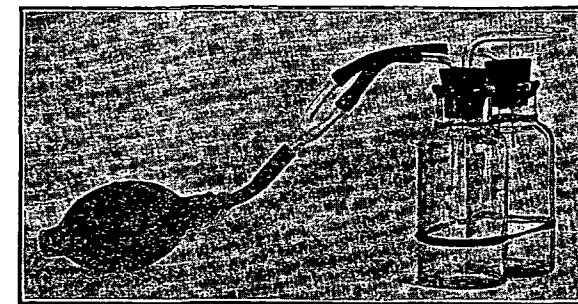


FIG. 2. AMMONIUM CHLORIDE APPARATUS FOR DETERMINING VELOCITY AND DIRECTION OF AIR CURRENTS.

in the last column headed Percent of Perfect. For example, if the sum of all “-%’s” found in the different columns is $15\frac{3}{8}$ per cent, then the difference between 100 and $15\frac{3}{8}$, or $84\frac{3}{8}$ per cent, is plotted in the last column as the final Percent of Perfect.

TO MAKE THE TEST

Temperature, Humidity, and Air Motion.—Temperatures and humidities shall be determined with a sling psychrometer. The extent and direction of air movement in the room may be determined by observing the velocity of a puff of vapor from an ammonium-chloride apparatus, such as shown in Fig. 2. This apparatus consists of a bottle of hydrochloric acid and a bottle of ammonium chloride, each bottle having a two-holed rubber stopper supplied with bent glass tubing similar to a wash bottle. A small pressure bulb forces the air through the two bottles simultaneously, and when

the acid vapors and the ammonium vapors unite, a cloud of ammonium-chloride vapor is formed. This cloud is readily visible and the velocity and direction of the air currents may be studied from it.

Dust. Dust determinations are made by the use of a direct-counting instrument in which the air is caused to impinge against a cover slip coated with adhesive material. The particles are counted under the microscope and the result placed upon a cubic foot basis. By direct counting is meant a method where the dust particles are studied and counted as they originally existed in the air, and the particles are not broken up or altered in shape, size, or nature by processes of sampling or counting.

Bacteria. Bacterial determinations shall be made in accordance with the standard adopted by the American Public Health Association. Petrii dishes 4 in. in diameter (see Fig. 3) containing standard agar, are exposed in the room for two minutes. They are then carefully covered and incubated for 48 hours at 22 deg. cent. The colonies on the plate are then counted.

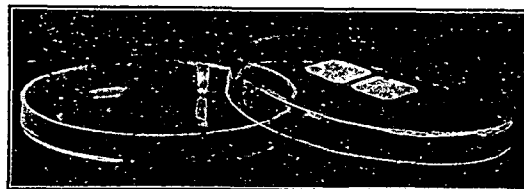


FIG. 3. CULTURE PLATES FOR DETERMINING THE BACTERIA IN AIR.

Odors. Odors shall be determined in accordance with the following rating:

100 per cent freedom from odors.....	Perfect
95 per cent freedom from odors.....	Very faint
90 per cent freedom from odors.....	Faint
85 per cent freedom from odors.....	Noticeable
80 per cent freedom from odors.....	Distinct
75 per cent freedom from odors.....	Decided
70 per cent freedom from odors.....	Strong

The determination shall be made immediately upon going into the room from the outer air.

Carbon Dioxide. The apparatus necessary to take samples of air for CO₂ determinations consists of a 120 cu. cm. rubber-stoppered bottle and a constant-pressure rubber bulb, as shown in Fig. 4. To take a sample, the rubber tube attached to the bulb is inserted to the bottom of the bottle and held at arm's length so that the sample will not become contaminated by expired air. The tube is closed by compressing it between the thumb and neck of the bottle and the net-covered bulb is filled with air by pressing the uncovered bulb with the hand; the thumb is then released and the intruding air re-

places the air originally in the bottle. This operation is repeated three times, after which the tube is removed and the bottle is tightly sealed with a rubber stopper. An analysis of the sample is then made with a Peterson-Palmquist air-analysis instrument, the result being given in parts of CO₂ per 10,000 parts of air.

In the chart in Fig. 5 is shown how the air supply may be determined from the CO₂ readings. Suppose an analysis of the air sample taken in the room shows that the average CO₂ content is 7 parts per 10,000. Then if the outdoor air contains 4 parts per 10,000, the difference is 3 parts. Locate the 3 on the horizontal scale of the



FIG. 4. TAKING AN AIR SAMPLE.

chart, and pass vertically up to the curve; from the point of intersection with the curve tranverse to the vertical scale which will show that 2000 cu. ft. of air per hour per person is being supplied to the room.

Distribution. The distribution of the air in a room shall be determined from the CO₂ readings taken in the various parts of the room. The following example illustrates the method of calculating the result. Assume four samples taken resulting in the following analysis:

Station	Parts of CO ₂ per 10,000
1	6.4
2	7.4
3	9.2
4	5.0
	Average 7.0

The variation at the various stations above or below the average is as follows:

Station	
1	7.0 - 6.4 = 0.6
2	7.4 - 7.0 = 0.4
3	9.2 - 7.0 = 2.2
4	7.0 - 5.0 = 2.0

Then the average variation from the average CO₂ is determined as follows:

$$\frac{0.6 + 0.4 + 2.2 + 2.0}{4} = 1.3$$

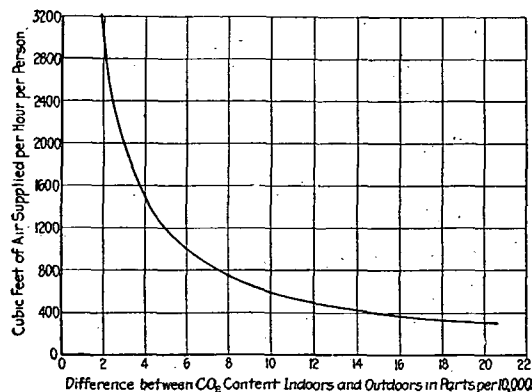


FIG. 5. CURVE TO DETERMINE AIR SUPPLY FROM CO₂ READINGS.

The percentage of variation is therefore equal to $1.3 \div 7.0 = 18.6$ per cent. Therefore the percentage distribution = $100 - 18.6 = 81.4$ per cent.

Other Injurious Substances. This column is used only in special cases where, owing to the nature of the processes carried on, some particularly injurious substance is being given off to the air. The column is then graduated, consistent with the nature of the substance.

For example, suppose that the contaminating substance is carbon monoxide. Grubner states that symptoms of poisoning are distinct when the air contains 0.02 of one per cent of this gas, and that death ensues in a short time when the air contains 0.05 of one per cent. Whitthaus states that when air containing carbon monoxide is breathed, the body retains about one-half of the gas inhaled. The poison therefore accumulates in the blood, and small amounts in the air may produce death if inhaled over a sufficient period of time. It is apparent therefore for our purpose that the lethal dose of 0.05 of one per cent is too high, and that 0.02 of one per cent, consider-

ing the time factor, would be nearer the truth. In arranging our scale in the column headed Other Injurious Substances, we would therefore consider air free from CO as 100 per cent and air containing two parts in 10,000 as 0 per cent, or air containing one part of CO would be 50 per cent, $\frac{1}{2}$ parts, 25 per cent, etc.

For example, if a test is made of the air in a garage or other place where CO is found, and the result shows two parts of CO in 100,000 parts of air, the penalization factor would be 10 per cent, and this amount would be added to the other minus percentages or penalization factors, and the total subtracted from 100 to obtain the final Percentage of Perfect.

The Comfort Chart. The inter-relation of temperature, humidity, and air motion is shown in the lower portion of the chart. The intersection of the Air Motion line and the Physical State line determines the proper wet bulb temperature. This point should be indicated on the chart by a small angle (thus $\angle$) the apex of the angle coinciding with the point of intersection of the lines. The observed dry bulb and wet bulb is also indicated by an angle (thus $\angle$). The difference between the desirable wet bulb and the observed wet bulb is plotted in the first column of the air chart marked Wet Bulb Difference.

Number and Location of Stations. The number of stations where samples are to be taken shall be determined from the floor area in the room. One station should be allowed for each 200 sq. ft. of floor space. In no case shall less than four samples be taken. The room should be divided equally into imaginary areas and a station located in the center of each area. All samples are to be taken in the breathing zone which is from 2 to 6 ft. from the floor.

RECORDING THE RESULTS

To illustrate the method of determining the Percentage of Perfect ventilation, consider the results of a test as given below. The average results in a room are found as follows:

Dry Bulb temperature.....	72°
Wet Bulb temperature.....	58°
Air Motion.....	20 ft. per min.
Physical State.....	Light work
Dust.....	10,000 particles per cu. ft.
Bacteria.....	10 colonies on a 2-minute plate
Odors.....	90% free from
CO ₂	7 parts per 10,000
Other injurious substances.....	None
Distribution.....	81.4

These values are now represented on the chart by a $\frac{1}{8}$ in. vertical line drawn in the center of each of the respective columns. The proper wet-bulb temperature is determined by noting the point of intersection of the "light work line" and the 20 ft. air motion line; this is 55 deg. wet bulb. Since the actual wet-bulb temperature as determined by the test is 58 deg. then the wet bulb difference is 3

deg. This value is plotted in the first column and the penalization as read in the "—%" portion is $-5\frac{3}{8}$ per cent. For the 10,000 particles of Dust, the penalization is a -1 per cent; for the Bacteria, -1 per cent; for the Odors $-1\frac{1}{2}$ per cent; for the CO_2 , $-\frac{7}{8}$ per cent; for Other Injurious Substances, -0 per cent, and for Distribution $-5\frac{3}{8}$ per cent. The sum of all these penalizations is $-15\frac{3}{8}$ per cent. Therefore the Percent of Perfect ventilation in the room is $100 - 15\frac{3}{8} = 84\frac{5}{8}$ per cent. This value is then plotted in the last column marked Percent of Perfect.

JOHN R. ALLEN,
DIRECTOR OF THE RESEARCH BUREAU.

CODE FOR TESTING LOW PRESSURE HEATING BOILERS

Revision of 1919

THE Code for Testing Low Pressure Heating Boilers was first accepted by the Society at the Annual Meeting, January, 1918, as the report of the Committee appointed to formulate it. It was accepted at the meeting with the provision, however, that it should be again submitted for discussion at the next Annual Meeting. The Code, in the form presented in 1918, was accordingly submitted at the 1919 Annual Meeting for general discussion, together with written discussions, and the following report of revisions was made and accepted.

Since that time the Code has been widely used and a committee has been appointed to make any further revisions which its application may make necessary or advisable.

CODE FOR CONDUCTING EVAPORATIVE PERFORMANCE TESTS ON LOW PRESSURE HEATING BOILERS

APPARATUS AND INSTRUMENTS

Feed water tanks may be calibrated or mounted on tested weighing scales, the water being fed to boiler by gravity, air pressure, or feed pumps.

Small accurate scales of suitable size shall be provided for weighing separator water.

Fuel and all fuel refuse shall be weighed on tested scales.

Draft measurements shall be made with differential draft gages of the inclined leg type, reading to 0.01 in.

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

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.

Boiler surfaces which are designed to be covered shall be insulated with 1½ in. of asbestos plastic cement or its equivalent.

Gas analysis shall be determined by means of an Orsat apparatus. If recording carbon dioxide (CO₂) instruments are provided, they shall be checked every hour with the Orsat.

Smoke observations shall be determined by means of a Ringlemann chart.

Weather bureau reports from immediate vicinity may be used to determine atmospheric conditions. When such reports are not available, a sling psychrometer shall be used for determining relative humidity and a calibrated aneroid barometer or mercury column shall be used for determining barometric pressure.

Steam pressure shall be determined by a calibrated steam gage or by a mercury column.

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

RULES FOR CONDUCTING EVAPORATIVE TEST

The primary object of the test is to determine the number of pounds of water evaporated per pound of dry fuel consumed. All measurements and readings should be taken with this object in view.

Boiler shall be carefully set and connected with a short, straight smoke-pipe to a chimney flue of suitable size and height to give proper draft. Chimney shall be tested for air leakage. Boiler shall be made smoke and gas tight and the gas passages properly cemented.

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, and ashpit shall be clean and free from soot, ashes and dust at beginning of test.

The piping shall be connected in such a way that the steam may be carried to a point away from the boiler and piping shall be arranged so that its condensation may not flow back to the boiler.

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 water shall be fed to the boiler continuously through suitable piping with all necessary valves, thermometer cups and connections so that the amount and temperature of water fed to the boiler can be determined at any time.

There shall be three draft gages so arranged as to determine pressure loss in the ashpit, pressure loss through the fuel bed, and pressure loss between firebox and smokehood.

ATMOSPHERIC TEST

The steam delivery pipe shall be open to the atmosphere.

PRESSURE TEST

The boiler pressure shall not exceed 8 lb. and the steam shall discharge through a suitable reducing valve into a chamber where a uniform pressure of two (2) pounds shall be maintained. The steam is to be finally discharged to the atmosphere through an orifice or graduated needle valve, which shall be used to control boiler capacity.

DURATION OF TEST

The duration of test should not be less than two firing periods and at least 12 hours in length. Longer tests are desirable but the length of test should always be some multiple of the firing period.

METHOD OF STARTING AND STOPPING TEST

The new fire method of starting and stopping test may be used on boilers having a fuel capacity of 15 cu. ft. or less from grate to center of fire door, when anthracite coal is used as fuel.

Boilers having a fuel capacity greater than 15 cu. ft. when using anthracite coal shall be tested by the Continuous Firing Method. All tests using bituminous coal shall be conducted by the Continuous Firing Method.

NEW FIRE METHOD

Starting and Stopping.—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 cleaned 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 equal to 40 per cent of that of an equal weight of coal. The height of water line in gage glass shall be noted and recorded at the time preliminary fire is dumped. The water level shall be kept at this level as nearly as possible throughout the test and 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 the unburned fuel and ash shall be separated, and the weight of unburned fuel subtracted from total fuel charged. The remaining refuse shall be weighed and recorded as ash.

CONTINUOUS FIRING METHOD

Starting and Stopping.—A preliminary fire shall be made and the boiler operated under test conditions for at least one hour before starting the test.

The fire shall then be burned low, thoroughly cleaned and the remaining live fuel spread evenly over the grate as the foundation for the first test fuel charge. The thickness of the fuel shall be quickly estimated or measured. The height of water line in gage glass shall be noted and recorded. The time of these observations shall be considered the start of the test. A weighed charge of fuel shall then be fired. The ashpit shall be thoroughly cleaned and the test allowed to proceed.

A constant water level shall be maintained throughout the test.

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

GENERAL

The actual evaporation shall be considered the total water fed to the boiler less water removed from steam by separator.

During the progress of the test, regular samples shall be taken from the fuel charge and after quartering, sufficient sample shall be retained to fill two one-pint glass jars or other tight vessels.

These samples shall be preserved for subsequent determinations of moisture, calorific value, and chemical composition.

The residue taken from the ashpit shall be reduced by quartering to a quantity sufficient to fill two one-pint jars or other air tight vessels for subsequent chemical analysis.

RECORDS

Records of data shall be obtained as pointed out in the appended log sheet. Half hourly readings are usually sufficient. If there are sudden or wide fluctuations, the readings in such cases shall be taken every fifteen minutes or oftener.

REPORT FORM FOR TEST OF LOW PRESSURE HEATING BOILER

- 1.—Name and catalogue rating.....
- 2.—Grate surface; width....., length....., area.....
- 3.—Date of test..... No. of test.....
- 4.—Normal operating firing periods.....
- 5.—Duration of test.....
- 6.—Times fired.....
- 7.—Longest interval between firing.....
- 8.—Fuel, name..... Size.....
- 9.—Fuel, calorific value.....
- 10.—Fuel capacity pounds.....
- 11.—Fuel available (less re-kindling reserve).....
- 12.—Fuel available. Time will last, hours.....
- 13.—Fuel weight as fired, lb.....
- 14.—Fuel moisture, per cent.....
- 15.—Fuel weight fired, less moisture, lb. = (13)-(14).....
- 16.—Fuel weight unburned (including.. lb. recovered from ash pit).. lb.....
- 17.—Fuel burned in test, lb. = (15)-(16).....
- 18.—Fuel burned per hour, lb.....
- 19.—Fuel burned per sq. ft. grate per hour, lb.....
- 20.—Ashes, lb.....?
- 21.—Clinker, lb.....
- 22.—Combustible, per hour, lb.....
- 23.—Temperature, steam or flow, Fahr.....
- 24.—Temperature, feed water or return, Fahr.....
- 25.—Temperature, gases leaving boiler.....
- 26.—Temperature boiler room.....
- 27.—Temperature outside air.....
- 28.—Draft intensity in smoke pipe.....
- 29.—Draft intensity over fire.....
- 30.—Draft intensity in ash pit.....
- 31.—Friction loss through flue.....
- 32.—Friction loss through fuel.....
- 33.—Friction loss through inlet.....
- 34.—Steam pressure in boiler by gage.....
- 35.—Steam pressure in receiver by gage.....
- 36.—Percentage of moisture in steam.....
- 37.—Percentage of CO₂ in escaping gases..... per cent.
- 38.—Weight of water fed to boiler.....
- 39.—Weight of water evaporated, corrected for moisture in steam.....
- 40.—Equivalent evaporation from and at 212 degrees = (39) x total heat in steam above feed temp. ÷ 970.....
- 41.—Evaporation per hour of test.....
- 42.—Evaporation per lb. of coal as burned = (41) ÷ (18).....
- 43.—Evaporation per lb. of combustible = (41) ÷ (22).....
- 44.—Capacity, total available B.t.u. = (41) x total heat above feed temp.....
- 45.—Capacity per hour, B.t.u.....
- 46.—Capacity per sq. ft. radiation = (45) ÷ 240.....
- 47.—Efficiency of boiler = (45) ÷ (22) x B.t.u. per lb. combustible.....
- 48.—Efficiency of boiler and grate = (45) ÷ (18) x B.t.u. per lb. coal.....
- 49.—Losses, grate.....
- 50.—Losses, stack gas.....
- 51.—Losses, incomplete combustion.....
- 52.—Losses, unaccounted for.....
- 53.—Smoke pipe, size..... Length.....
- 54.—Chimney, size..... Height.....
- 55.—Draft..... Inches.....

RATING.

The rating as determined by this test shall be calculated by the following formula,—

$$\frac{C \times H}{T} = \text{Boiler capacity per hour in B.t.u.}$$

C = Number of pounds of dry fuel consumed (18)

T = Duration of firing period.

H = Total B.t.u. available at the boiler outlet per pound of dry fuel as shown by test, or (18) x (9) x (48)

Note.—The length of firing period will depend upon the size of boiler, kind of fuel and purpose of test.

REPORT OF COMMITTEE ON UNIFORM CONTRACT AND SPECIFICATIONS

(Transactions of A. S. H. V. E., Vol. IX, p. 336.)

The Society approved a revised uniform contract and specifications with the conditions classified as follows:

Qualifications of Bidders	Removal of Rubbish
Drawings and Specifications	Rules, Permits and Responsibilities
Assigning or Subletting	Insurance
Intention	Patent Devices
Architect or Engineer	Final Tests and Acceptance
Material and Workmanship	Payments
Alteration	Rejection of Material
Delay	Temporary Use of Apparatus
Care of Work	Arbitration

REPORT OF COMMITTEE ON CODE FOR TESTING DIRECT RADIATION HEATING PLANTS

(Transactions of A. S. H. V. E., Vol. IX, p. 347.)

The two fundamental requirements upon which the Code is based are:

1. That during the test the temperature of steam or water maintained in the radiators shall be the same as that allowed by the contract to be maintained in order to maintain a temperature of 70 deg. in the building when it is zero outside.
2. That during the test the difference between the temperature of the steam or water in the radiator and the temperature maintained inside of the building, shall not be less than 0.8 of the difference between the temperature of the steam or water in the radiator and the temperature maintained in the building when it is zero outside.

NOTE.—There is also a third requirement, viz., "that no test to determine the heating capacity of a system, to maintain a temperature of 70 deg. in a building during zero weather, shall be made when the temperature outside is greater than 48 deg., even although the allowable temperature under requirement 2 of the Code should be greater than 48 deg."

REPORT OF COMMITTEE ON STANDARD SIZES OF STEAM AND RETURN MAINS

(Transactions of A. S. H. V. E., Vol. XIII, p. 24.)

The standard recommended is "the use of such a velocity as will require a difference of pressure of *not more* than 1 oz. to 100 ft. in straight pipe to maintain it."

NOTE.—A new Committee, the Committee on Steam and Return Main Sizes was appointed at the recent Annual Meeting to review this former standardization work and bring it up to date.

REPORT OF COMMITTEE ON MINIMUM VENTILATION REQUIREMENTS FOR PUBLIC AND SEMI-PUBLIC BUILDINGS FOR LEGISLATION PURPOSES

After a careful study of modern ventilation practice the Committee presented at the January, 1915, meeting of the Society a comprehensive report, which was adopted and ordered printed with general notes inserted by the Council. This report consists principally of general suggestions for minimum heating and ventilation requirements that are applicable to all classes of buildings, and in addition separate and more specific requirements for schools, factories and theaters. This report in full may be obtained upon application to the office of the Society's Secretary.

The Committee's general statement of their findings and recommendations are here reproduced.

GENERAL STATEMENT

A correct interpretation of the experimental work which has been carried on, relating to ventilation practice, forces certain conclusions:

1. The necessity for adequate ventilation has been emphasized although the relative importance of certain factors has changed.
2. A high temperature, especially if associated with a high relative humidity, is injurious.
3. The proper relation between air temperature and relative humidity should be emphasized.
4. Air movement in contact with the body materially assists normal heat dissipation.
5. Air supply free from dust, bacteria and other contaminations is important.

We believe that the importance of the following requirements in compulsory ventilation laws have been amply demonstrated:

1. A minimum allotment per person of floor and air space based upon the nature of occupancy.
2. A quantitative minimum air supply requirement.
3. A carbon dioxide test for determining the quantity of air supply and its distribution.
4. A temperature range limitation.
5. The removal from the air of injurious substances arising from manufacturing processes or other causes.
6. Air exhaust requirements for special service rooms (toilets, locker rooms, etc.).
7. Definite requirements regarding the drawing, filing and approving of plans for both new and existing buildings, in which ventilating equipments are to be installed or changes in the equipment made.
8. Ample authority to enforce the law without recourse to civil action, and with sufficient operative and financial assistance to care for the clerical, field and technical details incurred by such enforcement.
9. The official body charged with the enforcement of such laws shall have authority to promulgate specific rules and regulations covering details of installation and operation not included in the law. Such rules and regulations must not conflict with the full intent and meaning of the law.

REPORT OF COMMITTEE ON CODE OF ETHICS

In order that the dignity of the engineering profession might be maintained on the highest ethical basis possible there was formulated by a joint committee of the *American Society of Civil Engineers*, the *American Institute of Mining Engineers*, the *American Society of Mechanical Engineers*, the *American Institute of Electrical Engineers* and the *AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS*, the following Code of Ethics.

This Code was presented at the January, 1922, Meeting of the Society and adopted with the recommendation that a committee be appointed to administer and enforce its provisions.

A 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.

REPORT OF COMMITTEE ON AUTOMATIC HEAT CONTROL

(Transactions, Vol. 24)

The Committee considered the problem of automatic heat control particularly with respect to its effect upon fuel conservation. The Report includes a survey of the different uses and advantages of control in various applications and is summarized by the following conclusions.

CONCLUSIONS

The installation of automatic temperature regulation, or system for prevention of excess temperature, is a justifiable investment for all heating systems inasmuch as it very positively contributes to:

1. Conservation of fuel.
2. Improvement in health.
3. Gain in personal efficiency.

Those installations in which it is particularly a desirable and wise addition, are:

1. All manufacturing plants in which a temperature of 60 deg. or higher is maintained.
2. All offices.
3. All residences. For the smaller residences the type which has but one thermostat, operating on the heater drafts, gives excellent results.
4. All buildings heated from central stations, and particularly those having steam service. For many of these the single unit type of control is ample.
5. All buildings having mechanical ventilation. The air changes are so rapid and involve such quick temperature fluctuations that automatic temperature regulation is imperative from the comfort standpoint as well as for many other reasons.
6. All service hot water heaters, particularly those having coils which are supplied with steam. The savings to be made are very great. Prevention of scalding is positive. Steam supply to the coils, or the drafts of the coal fired heater, or the supply of the gas fired heater may be controlled by automatic devices limiting the temperature of the water.
7. All manufacturing processes in which the exact control of the moisture contained in the air and the temperature of any of the materials are of importance.
8. All railway, elevated or street cars, particularly those heated by electricity, and used for the transportation of human beings.

AN ORDINANCE FOR CONSTRUCTION OF CHIMNEYS

Suitable for Use in Cities and Towns of Any Size

RECOMMENDED BY THE NATIONAL BOARD OF FIRE UNDERWRITERS COMMITTEE ON
CONSTRUCTION OF BUILDINGS, SECOND EDITION, REVISED 1921.

FOREWORD

THE average annual loss due to defective chimneys in the United States for the years 1916-1919, inclusive, and reported to the Actuarial Bureau of the National Board of Fire Underwriters was \$11,898,000. All losses were not reported and it is conservatively estimated that the complete actual loss was 25 per cent larger, thus making an approximate total loss per year of \$14,872,000. The number of lives sacrificed in the average 23,000 fires which produced this annual property loss is not known, but is unquestionably large.

Since fires from this cause are classed as *strictly preventable*, it should need no further argument to justify the promulgation of this ordinance, which is suitable for adoption by a town of any size, or for enactment as a state law.

Conservation of our national resources is the demand of the hour. It is, therefore, the duty of all state and municipal authorities to use their best endeavors to stop this great needless waste. The enforcement of a law requiring safe, smoke-tight construction of chimneys of ample size and height would be a sure means of accomplishing an immense saving in life and property as well as materially increasing home comforts.

Defective chimney fires would practically disappear if this ordinance were generally enforced, and since the additional cost of the construction herein recommended as compared with ordinary practice would seldom exceed \$10 to \$15 per chimney, the requirement would not be burdensome. The increased expense would be returned many fold due to saving of life and property and the efficient use of fuel.

The following organizations have reviewed this ordinance and approved it as here presented:

AMERICAN INSTITUTE OF ARCHITECTS,
AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS,
ASSOCIATED TILE MANUFACTURERS,
CLAY PRODUCTS ASSOCIATION,
COMMON BRICK MANUFACTURERS' ASSOCIATION,
EASTERN CLAY PRODUCTS ASSOCIATION,
NATIONAL BOILER AND RADIATOR MANUFACTURERS ASSOCIATION,
NATIONAL BRICK MANUFACTURERS ASSOCIATION,
NATIONAL FIRE-PROTECTION ASSOCIATION,
NATIONAL LIME ASSOCIATION—EASTERN BUREAU,
NATIONAL LUMBER MANUFACTURERS' ASSOCIATION,
NATIONAL WARM AIR HEATING AND VENTILATING ASSOCIATION,
Also various independent architects and heating engineers having wide experience in the subject.

This broad endorsement gives the requirements a reputation for correctness which has not been accorded to any similar set of specifications hitherto prepared. It is, therefore, hoped the ordinance may receive generous public approval, and become a construction standard in cities and towns throughout the country. We urge its adoption.

COMMITTEE ON CONSTRUCTION
OF BUILDINGS, NATIONAL BOARD
OF FIRE UNDERWRITERS

E. T. CAIRNS, *Chairman*,
R. C. CHRISTOPHER,
F. W. DAY,
JOHN W. EMERY,
CHAS. H. HAHN,
J. A. KELSEY,
A. W. PERRY,
E. G. PIEPER,
J. M. WENNSTROM.

The ordinance was drafted for the Committee by its Consulting Engineer, to whom correspondence in reference to same should be sent.

Address: IRA H. WOOLSON, *Consulting Engineer*, National Board of Fire Underwriters, 76 William Street, New York City.

AN ORDINANCE

PROVIDING MINIMUM REQUIREMENTS FOR PROPER AND SAFE
CONSTRUCTION OF CHIMNEYS, FLUES AND FIREPLACES IN
THE OF

SCOPE OF THE ORDINANCE

This ordinance does not apply to chimneys for high pressure boilers, furnaces used in manufacture, or for other heating appliances where high temperatures are maintained; but shall apply to all other chimneys which form a part of a building construction.

SECTION 1. CHIMNEY CONSTRUCTION

1. The walls of all chimneys to which this ordinance applies, whether the fuel used be wood, coal, gas or oil, shall be built of brick, concrete, stone, or hollow tile, of such thickness and construction as is hereafter specified, but this shall not preclude the use of a metal smoke-stack when located inside of a vent shaft having walls not less than 8 in. thick, and having an air space between the walls and stack on all sides.
2. Brick chimneys shall be built of solid brick, or may be built of perforated radial brick manufactured for the purpose and adapted to withstand high temperatures, but no other hollow brick shall be used.
3. The walls of brick chimneys shall be not less than $3\frac{3}{4}$ in. thick (width of a standard size brick), and shall be lined with fire clay flue lining.
4. Flue lining may be omitted in brick chimneys for private dwellings provided the walls of the chimneys are not less than 8 in. thick, and that the inner course shall be a refractory clay brick having a softening point of at least 1922 deg. fahr. (Seger cone 05). See Appendix 1 and 2.
5. Perforated radial brick chimneys may be unlined, provided the brick shall have a softening point of not less than 1994 deg. fahr. (Seger cone 03), and shall be not less than $7\frac{1}{2}$ in. in radial thickness, except that when such chimney is located inside a vent shaft having walls not less than 8 in. thick, the thickness of the chimney wall may be determined by engineering design. The brick shall be shaped to the circular and radial lines of the various sections of the shaft so as to form even joints.

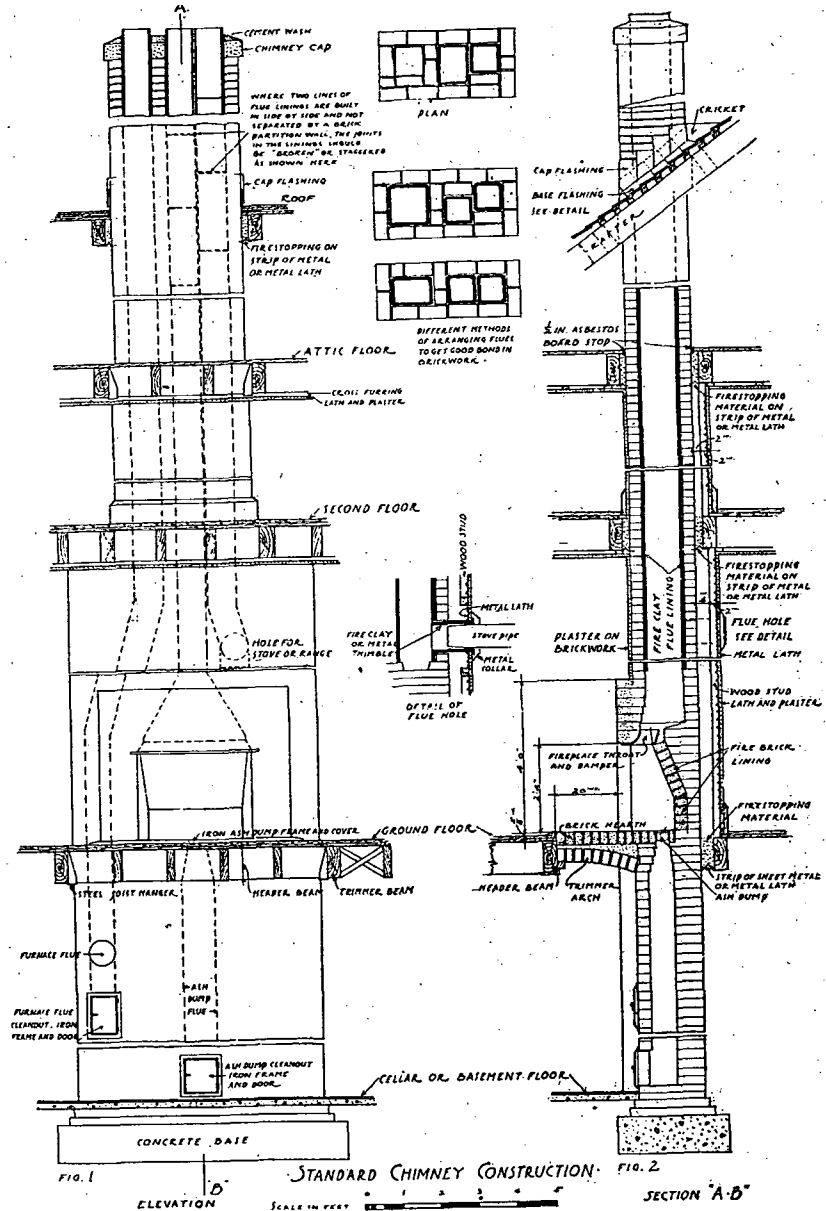


PLATE I.

Elevation and section of an interior independent chimney showing recommended construction. Extra flues can be added as desired.

6. 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 permitted.

7. Concrete chimneys cast in place shall be suitably reinforced vertically and horizontally. The walls shall be not less than $3\frac{3}{4}$ in. thick and shall be lined with fire clay flue lining.

Flue linings may be omitted in reinforced concrete chimneys for private dwellings, provided the walls of the chimneys be not less than 6 in. thick, and provided further that quartz gravel shall not be used as the coarse aggregate. See Appendix 3.

8. Concrete blocks used in chimney construction shall have walls not less than $3\frac{3}{4}$ in. thick, and blocks enclosing more than one flue shall have suitable reinforcement completely encircling the blocks and well embedded in them. All concrete block chimneys shall have fire clay flue lining. See Appendix 3.

9. Stone chimneys shall be at least 4 in. thicker than required for corresponding brick chimneys, and shall have fire clay flue linings. Rubble stone chimney walls shall be not less than 12 in. thick.

10. Hollow building tile shall not be used for the walls of isolated or independent chimneys, but may be used for chimneys built in connection with exterior hollow tile walls of buildings not exceeding three stories in height, in which case the chimney walls shall be not less than 8 in. thick. The outer 8 in. of a building wall may serve as the outside wall of the chimney, but the remaining chimney walls shall be constructed of two layers of 4-in. tile set with broken joints; or they may be built of 4 in. of solid brickwork. In either case the walls of the chimney shall be securely bonded into the wall of the building. No chimney shall be corbeled from a hollow tile wall. All chimneys built of hollow building tile shall have fire clay flue lining. See Appendix 4.

11. Chimneys shall be built at least 3 ft. above flat roofs, and 2 ft. above the ridges of peak roofs, and shall be properly capped with stone, terra cotta, concrete, cast iron, or other approved material; but no such cap or coping shall decrease the required flue area. See Plates I and II.

12. Fire clay flue linings shall be manufactured from suitable refractory clay, either natural or compounded, which has a softening point not lower than 1994 deg. Fahr. (Seger cone 03), and shall be adapted to withstand high temperatures and flue gases. They shall be of standard commercial thickness, but not less than $\frac{3}{4}$ in. The flue sections shall be set in mortar of quality hereafter specified 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 smokepipe intakes of flues, or from the throats of fireplaces, 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. wash and 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. Instead of the wash, a special chimney cap or coping may be used. Wherever flue linings are specified fire brick may be substituted if desired.

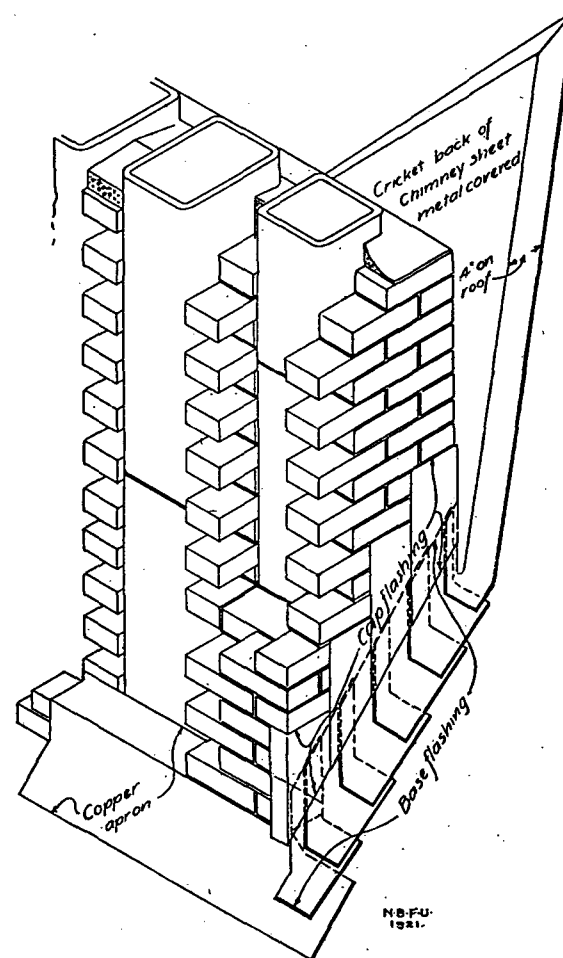


PLATE II.

Details of chimney construction showing method of flashing at roof surface also a wash course, but no cap surrounding flues at top. See Plate I.

13. Chimneys shall not rest upon nor be carried by wooden floors, beams or brackets, nor be hung from wooden rafters. Iron brackets or stirrups attached to wooden construction shall not be used to support chimneys. In frame buildings chimneys shall always be built from the ground up, or rest on basement walls.

14. Chimneys shall be built upon concrete or masonry foundations properly proportioned to carry the weight imposed without danger of settlement or cracking. The foundation for an exterior chimney shall start below the frost line.

15. The walls of brick buildings may form part of a chimney, but the walls of the chimney shall be securely bonded into the walls of the building, and the flue shall be lined the same as an independent chimney. Flues in party walls shall not extend beyond the center of the walls, and their location shall be permanently indicated on the exposed side of the wall.

16. No wall less than 12 in. thick shall be used to support a corbeled chimney; such corbeling shall not project more than 6 in. from the face of the wall, and in all such cases the corbeling shall consist of at least five courses of brick.

17. Flues shall be built as nearly vertical as possible, but in no case shall they have an angle greater than 45 deg. from the vertical. Where flues change direction, the abutting linings at the angle joints shall be chipped to fit closely, and at no point shall the cross section area be reduced. There shall be but one connection to a flue.

18. Not more than two flues shall be permitted in the same flue space, and the joints of any two adjoining sets of flue linings shall be offset at least 7 in. When there are more than two flues in a chimney, at least each third flue shall be separated from the others by a smoke-tight withe or division wall of brick or concrete at least $3\frac{3}{4}$ in. thick and bonded into the sidewalls. Each flue intended for a heating furnace or boiler connection, or for a fireplace, shall be separated from other flues by such a withe. In hollow tile chimneys the withe may be of tile. See Appendix 5.

19. When any single flue area within chimney walls exceeds 200 sq. in., the walls shall be built not less than 8 in. thick and shall have fire clay flue lining as previously specified, but when flues become so large as to render it impractical to secure fire clay flue lining, they shall be lined with fire brick for a distance of at least 25 ft. from the point of intake. Fire brick shall be laid in fire clay mortar.

20. Connections between chimneys and roofs shall be made with sheet-metal counter or cap flashing (copper recommended), arranged to overlap roof flashing and allow for movement that may occur between chimneys and roofs. See Plates I and II.

21. No increase in the wall thickness of chimneys, nor any projecting masonry, shall be permitted within a distance of 12 in. above or below the rafters or roof joists.

22. Irrespective of whether the fuel used be coal, coke, wood, or oil, the minimum area inside of chimney flue linings for various heating devices shall be as follows: for warm air furnaces, or low-pressure steam or hot-water heating boilers, not less than 75 sq. in.; for fireplaces, not less than one-tenth the area of the fireplace opening, but never less than 75 sq. in.; for stoves, ranges, and other forms of room heaters, 49 sq. in. for rectangular flues, or an inside diameter of 7 in. for round flues. In

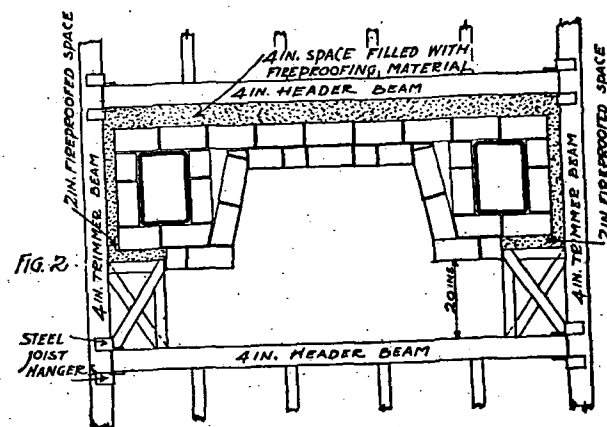
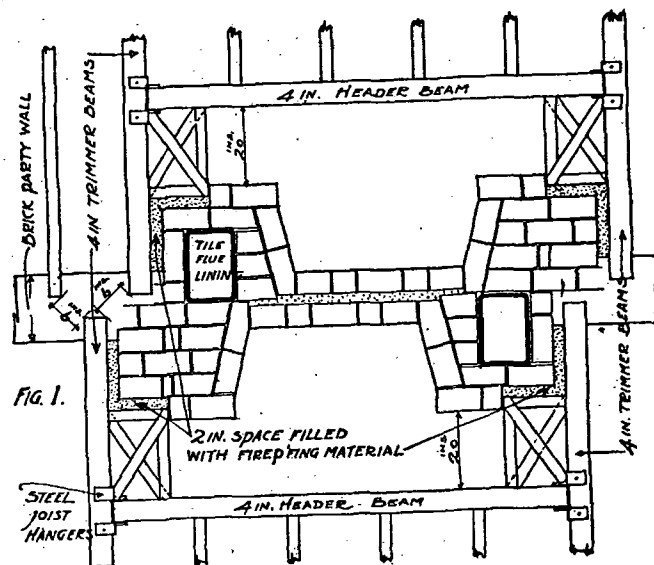


PLATE III.

Fig. 1.—Method for building two fireplaces back-to-back in a brick party wall to secure proper spacing between ends of floor joists.
Fig. 2.—Floor framing around a single fireplace. Note filling between framing and brick-work, which serves both as insulator and fire-stop.

no case shall the short cross section dimension of a rectangular flue be less than two-thirds the greater dimension. See Appendix 6.

When gas is the fuel used in a heating furnace, boiler, or automatic hot water heater, the flues shall be of the same size and construction as required for stoves and ranges using other fuel. Vent flues where required for other domestic gas burning appliances may be of smaller size, but not less than 10 sq. in. Such flues shall be made of fire clay or its equivalent not less than 1 in. thick with joints properly designed to effect a permanent seal, and the surrounding masonry walls may be omitted. Metal vent flues are not permitted.

23. Smokepipe intakes to flues shall always enter the chimney through the side and shall consist of fire clay or metal thimbles securely set in the chimney wall with mortar, or the intake may be cast in concrete. Such openings shall be at least 18 in. below wooden lath and plaster or other combustible ceilings, or open joists. Neither the intake pipe nor thimble shall project into the flue. No woodwork shall be placed within 6 in. of the thimble. The thimble shall be surrounded by metal lath and plaster for a space of at least 6 in., or an open space of that width shall be provided on all sides. See detail sketch Plate I.

24. All mortar used in chimney construction, except as specified for fire brick in Par. 19, shall be cement mortar proportioned as follows: two bags of Portland cement, not less than 188 lb., and one bag of dry hydrated lime, 50 lb., thoroughly mixed dry. To this mixture shall be added three times its volume of clean, sharp sand with sufficient water to produce proper consistency. When dry hydrated lime is not available, 1 cu. ft. of completely slaked lime putty may be substituted for 50 lb. of dry hydrate. In case of such substitution, the mixing of lime and cement shall be very thorough. Dry hydrate should always be used in preference to lime putty.

25. After a chimney has been completed, all flues shall be thoroughly cleaned and left smooth on the inside.

26. All flues to which heating furnaces or boilers are to be connected shall be subjected to a smoke test before acceptance, but the test shall not be made until the mortar has thoroughly hardened. The method of test is to build a smudge fire at bottom of the flue and while the smoke is flowing freely from the flue, close it tightly at the top. Escape of smoke into other flues or through the chimney walls indicates openings that shall be made tight before the chimney is accepted. The test shall be made by the contractor in the presence of the building inspector or other official having jurisdiction, and of the owner or his representative.

SECTION 2. WOODWORK AROUND CHIMNEY

1. No wooden beams, joists or rafters shall be placed within 2 in. of the outside face of chimneys, whether the same be for smoke, air or any other purpose. No woodwork shall be placed within 4 in. of the back wall of any fireplace. See Plate III, Fig. 2, and Plate IV, Fig. 4.

2. All spaces between chimneys and wooden joists or beams shall be filled with loose cinders, loose mortar refuse, gypsum block, or other porous incombustible material to form a firestop. See Plates I, III and IV.

The incombustible material shall be supported by strips of sheet metal or metal lath set into the brickwork and nailed to the wooden beams, form-

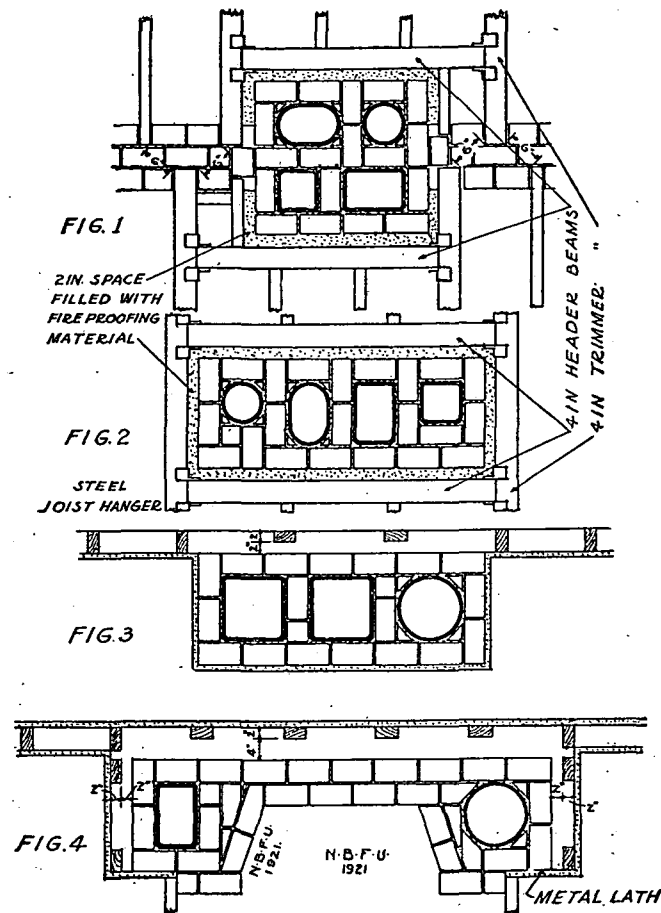


PLATE IV.

Fig. 1.—Floor framing around chimney in a party wall, to secure proper space between ends of floor joists.

Fig. 2.—Ordinary floor framing around a chimney. All timbers 2 inches clear of brickwork and space filled with fireproofing material.

Fig. 3.—Stud partition across back of a chimney showing proper method of arranging studs.

Fig. 4.—Stud partition across back of a fireplace and around the ends of the chimney breast, showing proper arrangement of studs. Method of fire-stopping this space is shown on chimney section, Plate I, also in Fig. 2, Plate III.

ing a buckled flexible joint between, as indicated in Plate I; or by similar strips of metal nailed to the woodwork with the inner edge close to the chimney. See Plate V.

3. No wooden studding, furring, lathing, or plugging shall be placed against any chimney, or in the joints thereof. Wooden construction shall either be set away from the chimneys, or the plastering shall be directly on the masonry or on metal lathing or on incombustible furring material. Wood furring strips placed around chimneys to support base or other trim shall be insulated from the masonry by asbestos paper, at least $\frac{1}{8}$ in. thick, and metal wall plugs or approved incombustible nail holding devices attached to the wall surface shall be used for nailing. See Plate V.

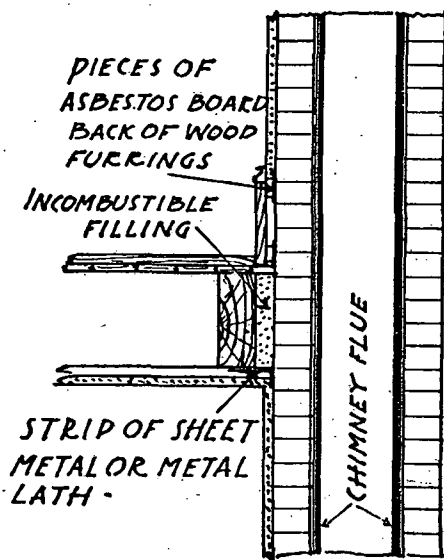


PLATE V.

Detail showing support for fire-stopping around chimney, and protection for woodwork placed next to plaster on chimney brickwork.

4. The walls of fireplaces shall never be less than 8 in. thick, and if built of stone the minimum thickness shall be 12 in.

5. All fireplaces and chimney breasts shall have trimmer arches or other approved fire-resistive construction supporting hearths. The arches and hearths shall be at least 20 in. wide measured from the face of the chimney breast. The arches shall be of brick, stone or hollow tile, not less than 4 in. thick. A flat stone or a reinforced concrete slab may be used to carry the hearth instead of an arch if it be properly supported and a suitable fill be provided between it and the hearth. The length of trimmer arches and hearths shall be not less than 24 in. longer than the fireplace opening. Hearths shall be of brick, stone, tile, or concrete as may be specified. Wood centering under a trimmer arch shall be removed before plastering the ceilings beneath.

6. No coal burning heater shall be placed in a fireplace which does not conform to the foregoing requirements and have an incombustible mantel.

7. No wooden mantel or other woodwork shall be placed within 8 in. of the side or within 12 in. of the top of any open fireplace. No combustible summer piece or fire board shall be used.

8. Any person or persons, whether owner, builder or mechanic, who shall build a chimney or flue in violation of any requirement of this ordinance shall be deemed guilty of a misdemeanor and shall be fined not less than \$10 nor more than \$..... for each offense; and any chimney or flue which is built in violation of any requirement of this ordinance shall be immediately demolished or rebuilt. It shall be the duty of the building inspector or other duly authorized official to enforce this ordinance.

9. All ordinances or parts of ordinances in conflict with this ordinance are hereby repealed.

10. This ordinance shall take effect upon being approved by the

APPENDIX

This appendix contains reasons for certain requirements in the ordinance, and various suggestions for good practice not suitable to be included in the ordinance itself, but which are thought to be useful information to accompany it. The material is, therefore, appended for its educational value, and a municipality in adopting the ordinance can dispose of the appendix as it sees fit.

1. HEAT RESISTANCE OF BRICK

Brick meeting the temperature requirement of Section 1, Par. 4, of the ordinance can be obtained in all sections of the country at a slight cost above that of ordinary brick. In several regions the ordinary brick of the market will meet the requirement, and in such places there would be no additional cost.

It is suggested that each manufacturer of flue linings or heat-resisting brick suitable for chimney lining should have tests made of the softening point of the clays used in the manufacture of such products. Such tests should be made by a laboratory of recognized standing, and the test certificate would constitute the authority for acceptance of the product as fulfilling the requirements, provided suitable identification marks were placed on the material. This would be a simple method of accomplishing the object, and the quality of clay from any particular bank is sufficiently uniform to secure reliable results.

2. THICKNESS OF EXTERIOR CHIMNEY WALLS

For exterior chimneys, or chimneys having any wall exposed to the weather, it is recommended that all such exposed walls be not less than 8 in. thick even though lined. This additional thickness will produce a more uniform temperature in the flue, thereby greatly improving the draft, which will result in fuel economy and a lessening of smoke annoyance.

3. CONCRETE CHIMNEYS

Pure quartz gravel or other highly silicious gravel concretes are not adapted to withstand high temperatures, therefore should not be used where subject to direct attack of heat.

The reinforcement required in concrete chimneys cast as a unit, or when built of large blocks enclosing more than one flue, is to resist stresses due to temperature variations or unequal settlement of foundations.

4. FILLING OF HOLLOW BUILDING TILE

When chimney walls are built of hollow tile as provided in Section 1, Par 10, it is recommended that the inner course of cells next to the flue lining be filled with mortar.

5. WITHEs.

A withe between at least every second and third flue in a chimney space is strictly necessary to insure stability of the chimney. A withe also aids in securing uniform temperature in a flue, and prevents air leakage, thus promoting good draft and fuel economy. At the same time it prevents possibility of a fire in one flue communicating to the others. For these reasons every flue connected with a fireplace or heating furnace of any type is required to be separated from other flues by such withes. The ideal chimney would have all flues separated by withes. See Plate IV.

6. AREA AND HEIGHTS OF CHIMNEYS

To secure the most satisfactory draft conditions, the area and height of a chimney should be proportional to the size and character of heating appliance attached to it. A poor draft is a great annoyance, and is difficult to remedy after a chimney is built.

A round flue will give a better draft than a square or other rectangular shape having the same cross-sectional area. Round flues are recommended where it is practical to obtain them, but when round flue linings are placed inside rectangular chimney walls, care must be exercised to insure complete filling of the corner spaces, otherwise there is liable to be air leakage into the vacant spaces, which injures the draft and increases the fire hazard.

Table 1 gives the approximate area and height of chimneys recommended by the furnace and boiler manufacturers associations as suitable to produce proper draft for heating equipment of different kinds and varying sizes when coal or coke is the fuel used.

The *American Institute of Architects* and the *AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS* have withheld approval of this table on the ground that it is not yet a sufficiently recognized standard to warrant its being accepted as a satisfactory guide in all cases. The other endorsers of the ordinance have not expressed an opinion on this matter.

7. SUGGESTIONS FOR REPAIR OF OLD UNLINED CHIMNEYS

1. A chimney in any existing building that becomes too hot to hold the hand against comfortably is dangerous if there is woodwork touching it. Have it carefully inspected by a reliable mason, and apply the protection prescribed by this ordinance as far as is possible.

2. The smoke test as described in Section 1, Par. 26, is strongly recommended as the best method for discovering defects in chimney walls which always indicate danger. If smoke escapes through the chimney walls at any place the chimney should be repointed or rebuilt as conditions may warrant.

3. Where soft coal is used it is often necessary to rebuild unlined chimney tops every few years, and all unlined chimneys, irrespective of fuel used, are very liable to become defective through disintegration of the mortar joints. In order to ascertain if chimneys need rebuilding, climb to the top and look inside. If mortar has begun to fall out from between the bricks it will soon do so all the way through the wall. Take an ice pick, a table knife, or other sharp implement and try to push it through the mortar; if you can do so, rebuild at once as follows:

Tear the chimney down to a point where mortar joints are solid, but at least 18 in. below the roof, get fire clay flue lining of the same size as the inside measurement of the chimney, set it in the top of the flue and build up with good brick and Portland cement mortar. This will make a solid chimney through the roof where there is greatest danger, and is the best that can be done unless the chimney is completely torn down and rebuilt. Preserve a clear space of at least 1 in. between the woodwork of the roof and the chimney wall, and connect the chimney with the roof by metal flashings. Build to a height above the roof as specified in Section 1, paragraph 11, of the ordinance.

MINIMUM CHIMNEY FLUE SIZES AND HEIGHTS RECOMMENDED FOR FURNACES AND LOW PRESSURE STEAM AND HOT WATER BOILERS

Area dimensions given are inside measurements of the masonry walls of the chimney

BOILER CAPACITY		NUMBER OF HEATERS ATTACHED TO FLUE							
		1		2		3		4	
		Dimensions Inches	Height Feet	Dimensions Inches	Height Feet	Dimensions Inches	Height Feet	Dimensions Inches	Height Feet
Warm Air Furnace Capacity in Leader Pipe Sq. In.	To 450 800 1000	8 x 12 8 x 12 8 x 12	35 35 40	12 x 16 16 x 20 20 x 24	45 50 55	16 x 20 20 x 24 24 x 28	50 55 60	20 x 20 24 x 24 28 x 28	55 60 65
Hot Water Rating Sq. Ft.	To 700 900 1100 1500 2500 4000 5800 7500 8700 10000 12000 14000 15000 17000 19000	12 x 12 12 x 12 12 x 12 12 x 12 12 x 16 16 x 16 16 x 20 20 x 20 20 x 24 24 x 24 24 x 28 28 x 28 28 x 32 30 x 30	35 40 45 50 55 60 65 70 75 80 85 90 95 100 105	24 x 28 28 x 32 32 x 36 36 x 40 40 x 44 44 x 48 48 x 52 52 x 56 56 x 60 60 x 64 64 x 68 68 x 72 72 x 76 76 x 80	60 65 70 75 80 85 90 95 100 105 110 115 120 125 130	30 x 30 30 x 36 36 x 42 42 x 48 48 x 54 54 x 60 60 x 66 66 x 72 72 x 78 78 x 84 84 x 90 90 x 96 96 x 102 102 x 108	70 75 80 85 90 95 100 105 110 115 120 125 130 135 140 145 150	30 x 36 36 x 42 42 x 48 48 x 54 54 x 60 60 x 66 66 x 72 72 x 78 78 x 84 84 x 90 90 x 96 96 x 102 102 x 108 108 x 114 114 x 120	80 85 90 95 100 105 110 115 120 125 130 135 140 145 150
Steam (Direct) Rating Sq. Ft.	To 450 600 700 1000 1500 2500 4000 5800 7500 8700 10000 12000 14000 15000 17000 19000	8 x 12 8 x 12 8 x 12 12 x 12 12 x 12 12 x 16 16 x 16 16 x 20 20 x 20 20 x 24 24 x 24 24 x 28 28 x 28 28 x 32 30 x 30	35 35 40 40 45 45 50 55 60 65 70 75 80 85 90	12 x 16 16 x 20 20 x 24 24 x 28 28 x 32 32 x 36 36 x 40 40 x 44 44 x 48 48 x 52 52 x 56 56 x 60 60 x 64 64 x 68 68 x 72	45 50 55 60 65 70 75 80 85 90 95 100 105 110 115	16 x 20 20 x 24 24 x 28 28 x 32 32 x 36 36 x 40 40 x 44 44 x 48 48 x 52 52 x 56 56 x 60 60 x 64 64 x 68 68 x 72 72 x 76	50 55 60 65 70 75 80 85 90 95 100 105 110 115 120 125	20 x 20 24 x 24 28 x 28 30 x 30 30 x 36 36 x 42 42 x 48 48 x 54 54 x 60 60 x 66 66 x 72 72 x 78 78 x 84 84 x 90 90 x 96 96 x 102	55 60 65 70 75 80 85 90 95 100 105 110 115 120 125 130 135

Where round tile flue lining is used in place of rectangular, the nearest corresponding area shall be taken.

8. CLEANING CHIMNEY FLUES

For efficient and safe operation of heating apparatus it is extremely important that both the flue and the smoke passages in the heating device be free from soot. When bituminous coal is used for fuel, soot accumulates quite rapidly and frequent cleanings are necessary.

Accumulation of soot in a chimney introduces the risk of a chimney fire with the consequent danger of sparks being thrown upon the roof or penetrating cracks in the chimney walls. *This is a very great hazard and is the reason why chimneys should never be purposely burned out to clean them.* The burning out of a tile lined flue is liable to crack the lining.

A common and efficient method of cleaning a chimney is to sweep it with a properly weighted bundle of rags or a bush attached to a rope and worked from the top, but because this operation is troublesome, chimney cleaning is frequently neglected.

Other methods of chimney cleaning recommended as simple and efficient are as follows:

1. The U. S. Fuel Administration has strongly advocated the use of salt. The fire should be put in good condition with a substantial body of hot fuel. Wet dried common salt is then scattered over the incandescent fuel in quantity depending upon the size of the furnace. For a household furnace, a pound at a time is ample. The dampers should be kept open to maintain the furnace temperature until the fumes entirely disappear. This usually takes about half an hour. The soot is disintegrated by the action of the salt fumes. Repeat the application as necessary.

This method is highly endorsed for cleaning boiler tubes and furnace passages. It does not interfere with the operation of the plant and neither brickwork nor metal is deteriorated.

It is known that a layer of tarry soot 1/16 in. thick on boiler tubes or furnace passages will decrease their heating efficiency 20 per cent, hence the necessity of keeping them clean. It is claimed that an occasional use of salt as described will keep both heating apparatus and flue free from soot.

2. An ex fire chief recommends firing a revolver loaded with one or two blank cartridges up a chimney flue to remove soot. He asserts it to be very effective and that no injury to the flue results. Precaution should be taken to shut off the flue opening or fireplace with an old blanket or piece of burlap to prevent the soot flying back into the room when it falls following the shot. This method requires that the fires be extinguished before it is applied.

3. Scrap zinc thrown on a hot fire is recommended as a soot remover. The zinc fumes are said to disintegrate the soot.

Zinc compounds are also sold for this purpose, but as several pounds of these zinc materials are recommended to be used at a time, they would be somewhat expensive.

9. EXTINGUISHING CHIMNEY FIRES

A handful or two of powdered sulphur thrown on a fire is claimed to be effective in extinguishing a soot fire in a chimney. It produces sulphur dioxide which extracts the oxygen from the air supply and so prevents combustion.

A few pounds of salt thrown in the flue at the top is an old and excellent remedy for a soot fire. Even a pail of sand, earth or ashes is helpful. Such materials, however, should be used with much care, if at all, when a fireplace connects with the chimney flue, for they would be liable to scatter the burning soot into the room where the fireplace is located.

HIGH TEMPERATURE DRYING

BY BURT S. HARRISON

BY popular usage the term Drying may include desiccation, dehydration, distillation, concentration, oxidation, baking, calcining, chemical actions due to heat, catalytic actions due to heat and the presence of a catalyzer agent, and in fact numerous processes which have no other connection with actual drying than that incidentally there may be some moisture present on the start which is quickly driven off by the heat.

Even the term "high temperature" is purely relative. A temperature of 200 deg. fahr. is high temperature in a process where for 100 years or more the standard of temperature has been from 120 to 140 deg. fahr.

On the other hand, in one instance, where producer gas of 120 B.t.u. value was being burned in a brick oven with a temperature of combustion of 1900 deg., we heated the air for combustion and the gas separately to 1000 deg. fahr., and then burned them with a resultant temperature of combustion of 3100 deg. fahr., as shown by Seger cones and the Wilson-Maeulin platinum-rhodium couple. The first step—the heating of the gas and air to 1000 deg., comes under the heading of high temperature heating; the second step—the burning at 3100 deg.—comes under the head of high temperature combustion.

The range from 200 to 1000 deg. is what we term *High Temperature Work* as applied to commercial drying or processing.

It is a well known fact that if a pound of coal is burned free in a large room, the combustion will be very slow, if indeed it does not cease altogether, though the volume of oxygen in the room is ample for the purpose. On the other hand, if the coal be confined in a small chamber and the same volume of air be passed rapidly over it in a thin stream, the combustion will be very rapid. The rate of combustion will depend directly upon the rate of oxygen supply to the flame, the rate of heat absorption of the fuel and inversely upon the heat radiation loss from the fire.

Oxidation is only slow combustion; therefore the same rule holds. In other words, oxidation in an oven depends upon temperature and actual contact with the surface of the materials. Without that contact, it will be only by the slow and uncertain process of diffusion that the oxygen can reach the material. It is analogous to the New Yorker who needs coal and knows that there is plenty at the mines, but because that supply

TABLE 1. RELATIVE EVAPORATION RATE FROM WATER SURFACES DUE TO AIR MOTION

	Large Area	Med. Area (25 sq. ft.)	Small Area
Still air	1	1.5	3
250 ft. v.p.m.	3	3.5	4
800 ft. " (any area) ..		4.5	
1000 ft. " " " ..		4.8	
2500 ft. " " " ..		8.1	
4000 ft. " " " ..		12.6	

is not close enough to him for intimate contact, he waits for the arrival of small quantities over a system of freight-clogged railroads. Furthermore, as the freight leaving New York, in the direction of the coal mines, interferes with the arrival of the coal by clogging the line, so the gases given off from the oxidizing surfaces further retard and dilute the effects of diffusion in a drier.

Where the problem is one of evaporation instead of oxidation, these conditions still hold good, though not quite to the same extent unless the moisture has to be pulled from a material which gives it up reluctantly. Tables 1 and 2 give the relative effects of increased temperatures and of increased velocities of air over water evaporating surfaces. They are the application to our own use of figures by Box and Dalton, modified in accordance with the results of our own tests.

If the air velocity and the temperature are both increased, the relative evaporation rate is a product of both factors.

If the moisture of liquid to be evaporated is easily accessible to the air in the drier (i.e., not held inside of a fibre, or by capillary attraction, or by a deliquescent material) there is no economy in holding a higher working temperature than 212 to 220 deg. Fahr., provided an ample volume of heat is supplied. An excess of heat above what is required to evaporate the liquid will only superheat its vapor, which is ordinarily needless, unless to preclude any possibility of recondensation to the detriment of the material being dried. Speed may count for more than economy in the drier, when the output of a plant can be doubled with no additional overhead cost. Then the working temperature in the drier can be raised to advantage. When I say working temperature of a drier, I mean the *maintained* temperature and not the air supply temperature. Of course, in a progressive drier the working temperature at one end is the temperature of the entering air and at the other end, is that of the effluent air.

The time for drying any material is, as before stated, governed by the temperature, volume of air and the proper contact. The term "contact" covers the rapid motion of the air over the surface of the material. In other words, given the highest temperature which the material will stand, and with a proper amount of heated air supplied to the oven, if it is moved over the surface of the material so as to get equal distribution and good contact with the drying surfaces by means of a stiff velocity, the time of drying will be reduced to a minimum.

TABLE 2. RELATIVE EVAPORATION RATE FROM WATER SURFACE DUE TO HEAT

32° F. temp. of water and air	1
52°	2
72°	4
92°	8
112°	16
132°	27
152°	44
175°	71
195°	135
212°	165

To get this desired velocity of air over the surface without having to supply an excessive amount of air, we use where possible agitator fans within the driers. In some cases 5 or 6 of such fans to one air supply fan, which handle the air over and over until it has reached all surfaces and has picked up all the water vapor it can carry or has given up all the oxygen it can readily give.

Another point in favor of uniform distribution and high velocities is that if the gases given off are explosive or inflammable, the more quickly they are removed the better. An explosive gas with a small amount of air in a dead space is almost sure to ignite spontaneously as soon as the proper mixture is reached at high temperature. The same gas if kept in motion will not readily ignite, and if it does, it simply flashes without explosive effect.

The gases given off from the lower surfaces in an oxidizing oven, particularly if the oven is overloaded or packed too closely, will, if allowed to stand, often dissolve and wipe off clean the coated surfaces from the goods above, in the case of japans, and if the colors are light linseed oil mixtures, these gases will always discolor them if not removed quickly. The tendency of these gases is to cling to the surfaces from which they emanate and prevent the air reaching them.

In any drying system where there are no critical temperatures, the admissible maximum working temperature is that above which the actual gain in speed, or output due to the increased temperature, is less in proportion than the increased cost of operation due to the increased temperature. Within the same temperature limits of the material, many materials produce much better results when dried quickly at high temperature, as follows:

Linseed oil bright colors dried at low temperature will fade, while if baked in moving hot air they will hold.

A material carrying oleic or fatty acids and ferments, if dried slowly, will not give up all of either, while under the high heat all the ferments are given up and all but a trace of the fatty acids. Ferments alone, even if not entirely drawn off by high heats, lose their power to act.

In the case of some fruits or vegetables, a relatively low temperature at high velocity is better than too high a temperature, but too low a temperature and too long a time, give a tough product.

The skin of plums or prunes must be punctured, and in the case of figs a gelatinous layer under the skin must be broken or they will never dry at any temperature, but will cook and turn color.

In the case of semi-liquids, pastes or slimes, the time varies considerably according to whether they are in suspension or solution. Anything in the nature of a glucoside usually dries quite slowly.

A delicate vegetable fibre will sometimes scorch or toast at comparatively low temperatures in contact with metal or in the presence of CO_2 gas, while in pure air it will stand a much higher temperature without any scorching. Foods may be cooked in moving hot air without radiant heat, but to toast or brown them, requires CO_2 gas in the hot air supplied.

Milk or eggs desiccated at 120 to 150 deg. on a drum, are not dried uniformly and in many cases a 2 per cent solution of acetic acid or formaldehyde is added to preserve them; at higher temperatures they cook when dried this way. But when atomized into air at even 300 deg. fahr., they dry in one or two seconds to a powder of absolute uniformity which requires no preservative and which will a year afterward readily dissolve in ice water, in a few moments.

Hay, alfalfa, pine grass and clover, when dried in 20 minutes at 300 deg. in moving air, keep their original color and odor and have lost all ferments.

Copra (dried coconut meat), dried slowly at 150 deg. or less, retains oleic acid and ferments and will slime and mould in moist hot air, while if dried at high temperature in rapidly moving air (155 to 200 deg. fahr.) loses its ferments, contains about 3/10 of 1 per cent of oleic acid, 69 per cent of highest grade Cochin oil instead of 59 per cent, and will not slime. It will keep at least one year (as we have proven) without deterioration, and maggots and copra bugs will not touch it. Any one who has once smelled rancid copra will appreciate what this means.

Acetic acid vaporized and superheated to 1022 deg. fahr. (the temperature of dissociation of the steam) will condense at the discharge side of the system as acetone, the CO_2 escaping.

Asphalt japan coatings raised from 250 to 400 deg. fahr. will give up the petrolene, residuum oil or other vehicle, and harden in 2 to 3 hours.

Starch dried at 180 deg., moistened with diatase or dilute acid and raised to 400 deg., will in 8 hours turn to dextrine and at higher temperatures to dextrose.

Anthracene and creosote oil compounds bake to form electric insulation articles in 8 to 10 hours, while the lighter compounds, as coatings on paper and cloth, bake at about 300 deg. in a few moments.

Nitrites are made with air at 500 to 600 deg.

The drying of insulation blocks of asbestos, magnesia, and kieselguhr or diatomaceous earth in sheets, 4 in. thick, takes weeks at low temperatures and with radiant heat, and requires days at higher temperatures with direct flame, gas heat; but with hot air at high velocity at 600 to 800 deg. fahr. they dry in 8 hours.

In the dehydration or desiccation of some fruits and vegetables the oxidation of the contained enzymes or unorganized ferments, discolors the product so that peaches and apples turn brown and potatoes black. This does not in the least hurt the product but the people do not like the looks, so it is then treated with fumes of burning sulphur or other bleach-

ing agent, the discoloration is entirely removed and the product has a complexion as glaring and artificial as that of some of the women who buy it. In taste, however, it is unsatisfactory. Sulphur dioxide was never intended for human food.

Dr. Harvey W. Wiley, authority on pure foods, says: "Sulphur fumes, as I discovered in my experimental work with young men, are highly deleterious to health and should be excluded from objects of human food."

In the case of some vegetable fibres which give up the contained water very reluctantly, if the sulphur treatment is given prior to drying, the sulphur dioxide seems to take up some water and forms sulphurous acid which attacks the fibre and causes it to give up the remaining water quite readily, thus materially reducing the time of drying. Whether there remains a trace of the acid after drying, I do not know.

When the pure food laws are extended and enforced to prevent the sale of sulphur treated dried foods, there will be a large field for the production of wholesome desiccated fruits and vegetables. I am told that 80 per cent of the fresh fruit crop and 40 per cent of the fresh vegetable crop in this country are annually wasted.

DESIGN OF HIGH TEMPERATURE INSTALLATIONS

In installing high temperature plants each installation is distinctive and controlled by numerous controlling conditions. The plant is laid out for a maximum of speed or output, and to attain this presupposes all governing conditions to be favorable. The size, weight, shape and disposition of the material in the oven, and the proportion of free space have an effect on the result.

The specific gravity and thickness of a coating, and the method of mixing a coating or a compound have an effect, and sometimes a small variation in the composition or in the quality or purity of one element will prevent proper results, and above all, the human equation has to be considered. A certain firm worked up a material which had to be dried in slabs. The laboratory samples dried uniformly and within the desired time limits in the drier, at a certain temperature. When it was tried on a commercial scale, half of each batch refused to dry properly and the other half did not have all the properties of the samples. The measures or gauges for the different elements were checked and found to be exact. The elements were analyzed and found to be of a standard. Finally a watch was put on the man at the mixer.

Of all the elements which entered the compound, two were vital as they together formed the binder, which of course should be distributed evenly throughout the mass. He was putting them in separately at opposite ends of the mixer, running the machine forward for a few moments and then backward for the same time. The results were that these two ingredients never became intermixed. By putting these elements into the center of the mixer together, the block dried perfectly with all the characteristics of the laboratory samples. Several people lost considerable sleep, however, before the trouble was discovered.

It has been said that laboratory experiments do not tell the true story regarding an installation on a commercial scale. But, if, during the laboratory tests, the controlling conditions are made to approximate those of the commercial operation, they should and do tell the exact truth. All governing conditions, critical temperatures, time limits for chemical reactions, if any, and all data on the character of the materials to be handled, should be in hand for study before laying out the system.

Unfortunately, however, in most cases where high temperature drying can be applied to best effect, the client is either reluctant to give up any data for fear of giving away trade secrets, or he does not know many of the characteristics of the materials he handles.

All chemical actions are effected by heat, and the most of them are not completed, and some will not even start at all, without a certain critical temperature of heat. In the case of metathesis, where two separate chemical combinations are broken up and two or more totally different combinations are formed by the interchange of the elements of both groups, there are several actions or reactions at once. There seems to be no data on how much heat is absorbed by these actions.

Strange to say, in the case of many of the liquids, oils, gums, etc., in use for commercial purposes, the specific heat, and latent heat of evaporation and fusion, are unknown and one has to assume them to be the same as for water. Also a gum which will only melt when in bulk subjected to a temperature of 450 deg. fahr., as in a kettle, will carbonize when subjected, as a thin coating, to a temperature of 250 deg. fahr.

It is therefore necessary to do a considerable amount of testing in the laboratory in order to establish the controlling conditions in each case. The usual result is that when we have succeeded in fixing the critical temperatures, time limits, etc., and have cut the time for processing in half, the client immediately begins to figure where he can save some more money in the process and by the time the system is installed we find he has substituted creosote oil for anthracene oil, or fish oil for linseed oil, or he works in a non-hardening hydrocarbon oil, uses clay instead of magnicite, or in the case of a coating, puts it on twice as thick and makes one coat do for two.

In many cases the whole chemical formula is changed and notwithstanding the characteristics of the new material or coating, are totally different from the old, the manufacturer expects the results to correspond to the laboratory demonstration. From the manufacturer's point of view this is a good thing, for it sometimes enables him to cheapen the unit cost of his raw material as well as increasing the output by omitting elements which were required for the proper hardening at low temperatures while not for the high. But it leaves the engineer rather in the air until things have settled down to a standard of operation.

Hot dry air sometimes carries static electricity in a drier. This can often be overcome by putting a small steam spray into the air supply. Of course, this has to be taken care of in the amount of heat supplied,

as the steam must be superheated. A glucoside or a gum dried to a powder by atomizing the solution through a current of heater air will come down so charged with static electricity that it cannot be put into a glass bottle. Fabrics coated into an oven over a carding roll become so charged, even with well-grounded coating machines, that a static neutralizer is sometimes required to kill the effect.

In many processes the materials leaving the oven, when done, are soft from the heat and have to be conditioned in dry air. If the conditioning air is at too low a temperature, the goods will sweat and mould. The air should be as dry as possible but at normal temperature.

Linseed oil and varnish coatings which in commercial practice on large scale and in low temperatures of 155 to 160 deg., require 8 hours to dry, will dry in 1½ to 2 hours with the drier effluent at 220 deg. fahr., the air entering at 300 to 350 deg. fahr. By the addition of free oxygen I have dried them in the laboratory in 30 minutes.

In drying, the linolein of linseed oil takes up oxygen which changes the linoleic acid to linoxin, giving up glycerin which disappears as water vapor and carbonic acid gas. If heated too hot, acrolein escapes. One pound of linseed oil requires 0.17 lb. of oxygen to oxidize it. Therefore, assuming that all the oxygen were to be used up in the process of drying, the minimum amount to supply 1 lb. of oil would be 0.85 lb. of air or, say, 14 cu. ft. at 200 deg. fahr.

In rapid drying probably not over 10 per cent of the total oxygen component in the air is used up, so that 140 cu. ft. of air per lb. of oil, or say 1,000 cu. ft. per gallon, is about the minimum to supply.

No hard and fast rule for speed of drying for definite temperatures can be used with linseed oil, for the reason that it is affected by the quality of the oil, the method of extraction, the aging, and the boiling. The process of oxidation is started in the boiling of the oil, and is then restrained or intercepted by cooling, until when it is mixed in the coating and reaches the drier, the action is set up again to continue from where it left off.

If the boiling is not properly done, or is not carried to the proper point, the oxidation process will not have been sufficiently set up and the action in the drier will not be uniform. The addition of an artificial drier, as Japan drier or oil of powlownie, will not help matters, for it will discolor the finish and the coating will soon crack.

Aerated water has a highly oxidizing effect on metals. Oxygen being more readily soluble in water than nitrogen, the bubbles of air contained in the water often run as high as 40 per cent oxygen. Wrought iron pipes carrying aerated water rust very fast. Moist air is also highly oxidizing as shown by unprotected wrought iron left in a damp atmosphere.

But humidified air even at high temperature, has, as compared with dry air, a retarded oxidizing effect on linseed oil, varnish and other siccative coatings. This may be beneficial in the case of coatings on wood where too rapid hardening will cause craze cracks. For conditioning a dried surface, either dry air or a cold water spray will harden it, but a moist atmosphere, even if relatively cool, will not do so.

Since in the case of all such coatings, the process of oxidation is carried only far enough for a durable elastic surface, and never far enough for a carbonizing of the surface, I imagine the deterring effect of moisture

in the air is due to the glycerine still remaining in the coating, absorbing moisture and being prevented from hardening. In the case of the cold water spray, the cooling effect of the spray congealing or hardening the glycerine, overcomes its tendency to absorb moisture.

The use of ozone or ozonated air, we have found to be of little avail, beside costing too much for any benefit which might be derived. While text books tell us that the ozone (O_3) returns to the oxygen state (O_2) at 300 deg. fahr., our experience has been that at even 150 deg. fahr., it no longer has the oxidizing effect of nascent oxygen.

We have also tried desiccating water out of materials by means of electricity, the wet materials being placed in 1 in. thick layers between wire grilles or mats wired up as electric conductors, but the cost of the work is out of all proportion and the action is slow.

Superheating gas, air or steam is very much the same thing if the steam comes to the heater above 212 deg. fahr., or in other words, has the heat latent.

In the case of three outfits of the same size, one heating producer gas, one air and one acetic acid vapor, the delivery temperature in each case being 1000 deg. fahr., allowing for the fact that the acetic acid steam entered the heater at 212 deg. and the air and gas entered their heaters at 70 deg., the fuel consumption was as near identical as it well could be.

In the case, however, which we have recently had put up to us of heating air from 200 to 350 deg. fahr., the entering air carrying 300 gr. of water vapor per cu. ft., the heater capacity required is 16 times what it would be if the air were dry.

Superheated air, like superheated steam, loses its heat very rapidly if the greatest precaution is not taken.

At 400 to 450 deg. fahr., we have found the transmission losses from black iron ducts to be about 2.8 B.t.u. per sq. ft. per hour per deg. At the same temperature, with 3 in. of magnesia block and 1 in. of asbestos plaster, the loss ran 1.3 B.t.u. per sq. ft. per deg. per hour. At 600 to 800 deg. fahr., the loss from bare pipe ran 3 B.t.u. and with 3 in. magnesia and 1 in. plaster, it ran 1.5 B.t.u. per sq. ft. per degree.

It is therefore necessary to proportion the air supply piping quite carefully. The higher the velocity and the greater the volume of air passing through the duct, the less the temperature loss. It varies inversely as the velocity and the square of the volume of air passing through the duct.

Therefore the trunk line should be carried intact as far as possible and then if possible the branches all taken off together. The velocities should be kept as high as the predetermined horsepower limits for the fan will allow.

Of course, the higher the working temperature in the system the more unstable the air in it and to effectively control the distribution of the air and the maintenance of an equable temperature throughout the system requires a slight static maintained pressure in the oven or drier. I do not believe that in such a system a uniform temperature can be maintained without this pressure. The nearer the system can be adjusted to a state of static balance and still be on the plus side, the better.

We have adjusted driers or ovens 300 ft. long, 9 ft. wide and 14 ft. high so that with a working temperature of 237 deg. fahr., there was less than 1 deg. difference from floor to ceiling and from one end to the other, with 7000 cu. ft. of air per min. passing through. The hot air was admitted at the floor from 60 openings at 400 deg., and 60 vents at the ceiling carried off the gases. The doors to the oven were air locks so that there were no leaks. Fine mesh screens on the air opening tended to kill the velocity of incoming hot air and to distribute it over the floor.

When the ovens were closed so that the static pressure was maintained, the upward motion of the hot air from the floor was quite even throughout the horizontal area of the oven. With the doors open so that the static condition was removed, the hot air rose in separate currents.

These ovens were used to dry cloth in festoons or loops 11 ft. long suspended from sticks on a traveling chain at the top of the oven. The traveling chain tended to give a certain swaying motion to the cloth and any undue currents of air in the oven would cause the loops of cloth to touch each other. On account of the sticky coating and the static electricity it carried, if two loops touched at one point, they ran together nearly to the top. For this reason the air passing through the oven had to be under absolute control.

In the case of heavy material, or solid material piled on racks or cars, or suspended by rods, the motion of the air is not so important except as to its dust-carrying propensity, but the admission of the air at the floor is just as essential, as is also the slight static or plenum pressure, for the sake of even distribution and temperature. Also the light and heavy gases are forced out.

In a direct gas-flame-heated japan oven, the heavy gas given off has a chance sometimes to accumulate in the corners at the floor and is highly explosive. The temperatures in such an oven may vary from 1200 deg. at the flame to as low as 250 deg. in the corners near the floor.

In the case of a battery of cloth-impregnating towers, the cloth was drawn through pans at the base of the towers, thence traveled upward vertically, 40 ft., where it passed over rollers and returned to the bottom to be dipped again, the process being repeated. Six coats were to be applied in this way in rapid succession, and each coat dried during the time of one trip to the top of the tower and back. Of course it had to be sufficiently dry when it reached the top so that it would not stick to the roller.

The time for drying each coat was about 6 min. The minimum temperature required to do this was within 10 deg. of the ignition temperature of the compound (360 deg. fahr.). Radiant heat could not give an even heat throughout the tower, within the range; therefore we forced hot air in at the base.

We estimated the aspiring effect of the tower and closed in the top, leaving slots for the cloth to pass through and allowing for the gases to pass with a slight pressure. On trial we had to cut these slots down much smaller than the theoretical figures indicated, in order to hold the static pressure, but when this was adjusted, the

system worked and dried the coatings perfectly. Before such adjustment, however, the hot air shot to the top in as many currents as there were air inlets.

The use of high temperature air is not always economical or even applicable and some judgment must be used or the mark will be overshot or missed altogether. In one case where by the use of hot air and an increase of drier temperature of 25 per cent, the time of processing was reduced by 75 per cent and the client immediately tried to eliminate the remaining 25 per cent of time by increasing the temperature still more. The results were that the materials were all but ruined and he had to return to the temperatures we had established.

A technical firm wished to evaporate water vapor from a spray containing water and a heavier liquid. They found that at 220 deg. the process worked very much faster than at 160 deg. fahr. Therefore they reasoned that at 1200 deg. the work would be done in practically no time at all. The volume of air at 1200 deg. which would evaporate the water spray, would not have carried off the vapor. To supply sufficient air at the high temperature was too expensive. A careful computation proved that air at 300 deg. in sufficient volume was the most economical way to handle the problem.

Totally disregarding the difference in weight between air and water and the latent heat carried by steam, a number of schemes have been proposed to us for the use of air at 700 or 800 deg., in place of hot water in a radiator having a $\frac{3}{4}$ in. supply, or a die mold or steam kettle having a very large exposure for the area of opening for heat supply.

It has even been suggested that we boil liquid by blowing or bubbling hot air through it. For the aeration of boiling linseed oil this is very advantageous but the source of heat for the boiling is a direct fire underneath the kettle. In all three of these cases, to accomplish the work, the velocities of the heat carrying air would be terrific.

Another type of proposition which comes to us and which in nine cases out of ten is erroneous, is that a vapor recovery installation which by means of heat interchanges gives up a part of the heat of the effluent gases to the fresh air supply, and then by means of cold water and mechanical refrigeration condensing the vapors, will render large returns. In one case the first cost of the interchangers and condenser plant was estimated at close to \$1,000,000, the operating cost per day at \$250, and the total available gases for recovery were worth only \$160, assuming they could all be recovered. Incidentally, the whole manufacturing plant involved a cost not over \$1,000,000.

I have seen very few cases where such vapor recovery installations showed returns which warranted the investment. Waste heat recovery plants are a different proposition, however.

For high temperature work particularly, it is impractical to attempt dehumidification in order to use the same air over and over. The temptation in this seems to be great until the client sees the cost figured out.

Many clients cannot see why air entering the drier at 500 deg. fahr. should not hold the drier temperature at 500 deg., nor understand why the work done in the drier is only proportional to the difference between the entering and the effluent temperatures.

It is not an easy matter to obtain actual correct temperature readings in a drier without an expensive equipment, but fortunately, once the system is properly adjusted and the operators know at what level on their thermometers the heat should be, it does not make any difference whether the thermometer scales says 300 or 3000 deg., or whether there is a scale.

AIR HEATING TO HIGH TEMPERATURES

I will add just a few words regarding the heating of air to high temperatures. Our work in that line has all been done with the Aertube heater.

A large chemical firm wanted hot air at 1200 deg. fahr., to facilitate a certain chemical action. They concluded our heater was too large, heavy and expensive, and that they could get the same results by adapting a steam superheater with wrought iron tubes to their purpose. According to their own report on the result, in a very few hours the tubes had stopped up solid with their own rust on account of the high oxidizing effect of air at that temperature.

For such temperatures only cast iron, duriron, tantiron or similar metals should be used. Our first heater tubes were made of grey cast iron. The alternate heating to cherry red and cooling again, caused them to grow several inches in length in one season.

Professor Diedrichs of Cornell had found that growth in cast iron under such conditions was due to the silicon and graphitic carbon. We reduced the silicon to about 0.2 of 1 per cent and blew out the graphitic carbon in the blast and got a chilled tube which did not grow and which withstood a temperature of 2000 to 2100 deg. fahr.

Then the Duriron Castings Co. made an iron tube for us with 20 to 22 per cent of silicon in it which stands 2550 deg. fahr. and does not grow. In other words, we had passed from plus to minus through zero and they through infinity.

When heating gases carrying sulphur, we had to protect through rods and tried many different patent coatings, cements, etc., but were obliged to fall back on Portland cement mixed with buttermilk. This will stand temperatures up to 1200 deg. and is flexible. The Botfield Specialty Co. of Philadelphia make a fire cement which will stand 3000 deg. fahr. which we are now using with good success.

One thing which our work has proved to my satisfaction, at least, is that for the higher temperatures the steel plate fan, or the volume blower type, are better suited to the work than the multiblade or Sirocco type, particularly if the system requires operation at several temperatures or if at times parts of the system are shut off.

Suppose the fan handles 10,000 cu. ft. of air per min. at 60 deg. fahr. against a maintained pressure through the system of 1 oz., when there is no fire in the heater. Now if the heater is fired up and begins to deliver air at 580 deg. fahr., the maintained pressure in-

creases due to the expansion of the air in transit until it becomes 1.4 oz. and the multiblade fan falls off in its delivery, or else if it is installed for that pressure, it over-delivers a large amount at the lower temperatures.

Of course, in practice the fluctuation in temperature is not so extreme as I have stated, but when a compound contains light oils like benzoles and at the same time anthracene or creosote oil, it is a case of fractional distillation at several temperatures from 180 to 600 deg. fahr., and the most dangerous is the 600 deg. point at which there should be the maximum air delivery. To overcome this by multiple speed control of the fan is not advisable, as it introduces another element for the operator to look after.

Regarding the choice of fuels for this work, we have used wood, all kinds of coal, coke, producer, city and natural gas and distillate, kerosene, fuel oil and crude oil. Any gas or oil is easily subject to thermostatic control. Contrary to general belief, the easiest oil fuel to handle and control and the easiest on the heater and brickwork, as well as the cheapest, is the heaviest Tampico crude oil of 11 Beaume. When properly installed, and heated to 160 deg. before atomizing and when operated under thermostatic control, it gives a minimum of trouble.

In one plant where we installed such a system, and where the consumption of oil is something over 5000 gal. per day, they have replaced only 50 heater tubes in three years, though the total number of tubes in the heaters amounts to 6000.

It has been stated that in a water tube boiler with horizontal passes working under full load, the lower row of tubes sometimes carries 40 per cent of the total load. It might seem that in an air heater the same proportion or thereabouts would hold. This is not the case. When the gases of combustion are in sufficient quantity to fill the space between the tubes, or in other words, when the heater is working up to capacity, the proportion of the total load carried by the lower row of tubes is from 20 to 24 per cent as a maximum, there being eight rows of tubes in height above the fire. This is with the maximum combustion gas temperature of 2400 deg. fahr.

The transmission rate through the cast iron tubes from the hot gases to the air passing through the tubes, varies as the cube root of the velocity square of the air, and never exceeds 3 B.t.u.'s for velocities under 3000 ft. per min. So long as the hot gases do not exceed 2400 deg. fahr., very little tube replacement is necessary.

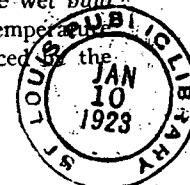
THE TEMPERATURE OF EVAPORATION ITS PRACTICAL APPLICATION TO AIR CONDITIONING AND TO THE DRYING AND CONDITIONING OF MATERIALS

By W. H. CARRIER, NEW YORK, N. Y.

Member

THE customary method of determining the moisture content of the air by means of the psychrometer is familiar to every heating and ventilating engineer. In this method simultaneous readings are taken of two thermometers, one of the usual type known as the dry bulb thermometer, the other known as the wet bulb, having the bulb covered with a film of water usually through a covering of wet fabric. The temperature indicated by the wet bulb thermometer is usually known as the wet bulb temperature, but the writer has chosen to call it the temperature of evaporation, for reasons which will be developed.

The significance of the wet bulb temperature and the physical laws governing it are not commonly understood. It is generally assumed that the wet bulb depression is due to cooling by evaporation and is determined by the rate of evaporation. It is true that it is caused by evaporation, but it is not at all determined by the rate of evaporation. For example, the rate of evaporation of a wet surface is three and one-half times as great at 4000 air velocity as it is at 1000 air velocity over the same surface and under like moisture and temperature conditions, yet the wet bulb depression is for all practical purposes precisely the same in both cases. It is very evident, therefore, that the wet bulb depression is not dependent upon the rate of evaporation, as is commonly believed, but upon other factors. The lower the moisture content of the air the greater will be the wet bulb depression, which goes to show that the wet bulb temperature has a very definite physical relation to the temperature and the moisture content of the air. It is also influenced



density and specific heat of the atmosphere. These relations have already been discussed by the author in a paper on Rational Psychrometric Formulae, presented before The American Society of Mechanical Engineers in 1911.

It is the writer's object in the present paper to explain more in detail these relations, to give more convenient and accurate formulae for the determination of the exact relation and to discuss the practical bearing of wet bulb temperature and vapor pressures in the art of air conditioning and upon the drying and moistening of hygroscopic materials.

It is well known that the weight of a cubic foot of saturated water vapor is a very definite quantity, dependent entirely upon its temperature, and that this water vapor acts substantially as a gas, producing a definite pressure, known as the vapor pressure. It obeys in this respect approximately the law of gases with reference to temperature, vapor pressure and weight or density. The vapor pressure and density increase very rapidly with the temperature, as exhibited in the well-known tables giving the properties of steam. The admixture of air under various barometric pressures as it occurs under ordinary atmospheric conditions does not in any way affect the weight per cubic foot or the pressure of the saturated vapor, but acts precisely the same as in a mixture of two gases. The combined pressure is equal to the total or barometric pressure; that is, the total weight of pure air in a mixture of a cubic foot of saturated vapor and air is less than the weight contained in a cubic foot of dry air just in proportion as the partial pressure of the air in the mixture is less than the total barometric pressure. This relation is expressed numerically as follows:—

$$W = \frac{S e}{P - e} = \frac{G_w}{G_a}$$

where W = the weight of water vapor contained in a pound of pure air, that is, it is the ratio of the weight of water;

G_w = to the weight of air;

G_a = in a given volume of the mixture;

P = the barometric pressure;

e = the vapor pressure of the water vapor;

$P - e$ = the partial pressure of the air;

S = the specific weight of water vapor, (i.e., the ratio of the weight of a cubic foot of water vapor at a given pressure and temperature compared with the

weight of a cubic foot of air at the same pressure and temperature).

From this relationship it is possible to find:

- 1st, The weight of moisture contained in or rather associated in space with a pound of pure air;
- 2nd, The ratio of the weight of pure air contained in a cubic foot of the mixture compared with the weight of a cubic foot of air at the same temperature and barometric pressure but containing no moisture;
- 3rd, The weight of moisture contained in a cubic foot of air.

In the last two determinations we also require the relation determining the weight of pure air at any given temperature and pressure, which is the well known relation

$$W_a = \frac{1}{V} = \frac{P}{3772T}$$

where W_a = the weight of one cubic foot of air;

V = the volume of one pound of air;

P = the barometric pressure or partial pressure in inches of mercury to which the air is subjected;

T = the absolute temperature in degrees fahrenheit.

When unsaturated air is brought in contact with water three physical changes take place simultaneously:—*first*, the water temperature is ultimately reduced to a definite temperature known as the wet bulb temperature; *second*, a certain amount of water is evaporated, increasing the vapor pressure and the water vapor content in the air; *third*, the air is cooled a corresponding amount, owing to the fact that finally the *latent heat of evaporation must be taken from the air as the only source of heat*. If this process is continued to the point of complete saturation of the air and no heat is received from the water or any other external source, then the air temperature will drop to a *definite point* which is the true wet bulb temperature or evaporation temperature of the air.

Thus the wet bulb temperature and the dry bulb temperature at this point of saturation are both the same, and the wet bulb temperature is substantially the same before the air has become saturated as after it has become saturated. In other words, the wet bulb temperature does not change during the process of saturation, but the dry bulb temperature decreases and the moisture content increases to some definite point at which the air is completely saturated. This fact has been determined by careful practical and laboratory experiments.

This is precisely the action that takes place in air conditioning.

equipment, in which air is passed through humidifiers or air washers where the water is recirculated and not heated, and it explains the seemingly remarkable effects sometimes produced. For example, in this climate it is sometimes possible to introduce humidified air into a room as much as 25 deg. cooler than the outside air, and maintain the room temperature approximately 15 deg. cooler than the outside dry bulb temperature, or 10 deg. above the outside wet bulb temperature; while in the excessively dry and hot climates of New Mexico and Arizona, where the wet bulb temperature often reaches 40 deg. fahr., telephone exchanges have been cooled in this manner as much as 25 deg. below the outside temperature without any refrigeration. In our cooler and moister Northern climates, however, in buildings, such as offices, restaurants, etc., where relatively small amounts of heat are liberated, the employment of this method of cooling by evaporation with air washers and humidifiers does not work out very satisfactorily. There will be occasional days, however, in summer even in these climates where great benefit will be procured in such buildings by this method of cooling. In all industrial establishments where high humidities are required or where considerable heat is liberated, the beneficial effects secured by this method of cooling are indisputable.

The same phenomenon of a constant wet bulb temperature with a dry bulb temperature dropping toward the wet bulb as the air absorbs moisture is beautifully illustrated in progressive fan system dryers. Here the air is introduced dry and hot at one end and comes out cool and moist at the other end of the drying tunnel. The wet bulb temperature will be found practically the same at all parts of the tunnel except for leakage or cooling by radiation through the tunnel walls.

The wet bulb temperature, or the temperature of evaporation, is thus seen to be a very definite physical quantity. It depends upon the ability of a definite weight of air to give up heat required for the evaporation of sufficient moisture to saturate its space at the temperature to which it is finally reduced in cooling. The difference between the wet and dry bulb temperatures of the air under any given barometric pressure is evidently an exact measure of what is commonly called the ability of the air to "absorb moisture," or more exactly, its ability to cause the evaporation of moisture into the space which the air occupies. It must always be kept clearly in mind that air does not "absorb moisture" as a sponge absorbs water, or through any chemical affinity, but only associates itself with water vapor purely as a gaseous mixture, the water vapor occupying exactly the same space as though there were no air present. The air will, how-

ever, occupy under a constant barometric pressure a slightly greater space than before, owing to the fact that it exerts a partial pressure which is less than the total or barometric pressure. The partial air pressure is reduced by an amount exactly equal to the increase of vapor pressure and the volume occupied by a given weight of air is therefore increased in an inverse proportion. This amount of increase, however, is very small at ordinary temperatures, since the possible vapor pressure under atmospheric conditions never exceeds 3 per cent of the total barometric pressure. Under artificial conditions, however, such as in drying and conditioning chambers at high temperatures, this may be several times the above amount.

When air is cooled solely by evaporation of moisture, it has been shown by theory and proven by experiment that the wet bulb temperature does not change appreciably. Conversely, any change in the wet bulb temperature would indicate a change in heat content. (By the heat content, or total heat of the air, we mean the sensible heat in the air due to its temperature above some standard, as 0 deg. fahr., together with the latent and sensible heat of the associated water vapor, but omitting the heat of the liquid, which may be assumed to be introduced or removed at the wet bulb temperature.)

As the air increases in moisture content and cools as a result, the sensible heat liberated by the change in temperature is merely converted into an equivalent amount of latent heat represented by the conversion of water into vapor associated with the air. Thus it is that the wet bulb temperature always indicates precisely the total heat content of the air regardless of its temperature or moisture condition. By calculating the heat content, or total heat of saturated air at various temperatures, the heat content of the air under all wet bulb conditions is definitely established, since the heat content is the same for a given wet bulb temperature as if it were saturated at that temperature. The fact that the wet bulb temperature establishes the heat content of the air is of great importance in calculating the requirements for the cooling and dehumidifying of air and for the humidifying of air, and also in the calculation of the cooling effect which may be secured in a building by the application of humidified air to maintain a definite standard of moisture condition or relative humidity. In problems in cooling and dehumidifying when using outside air, the outside wet bulb temperature is the fact of first importance.

It is of interest to note that the maximum wet bulb temperature in the Northern States rarely ever exceeds 78 deg. The highest outside wet bulb temperature ever observed by the writer was slightly over 81 deg. in New York City in 1917. This, it should be re-

marked, was accompanied by a low dry bulb temperature and a very high relative humidity. With the higher outside dry bulb temperatures, the moisture content of the air is invariably lower, so that higher wet bulb temperatures are to be expected, for example, at 85 deg. than at 95 or 100 deg. outside temperature.

In humidifying with an efficient central station system the air is taken from outside and cooled to the wet bulb temperature by evaporation, using recirculated water. When saturated air is heated,

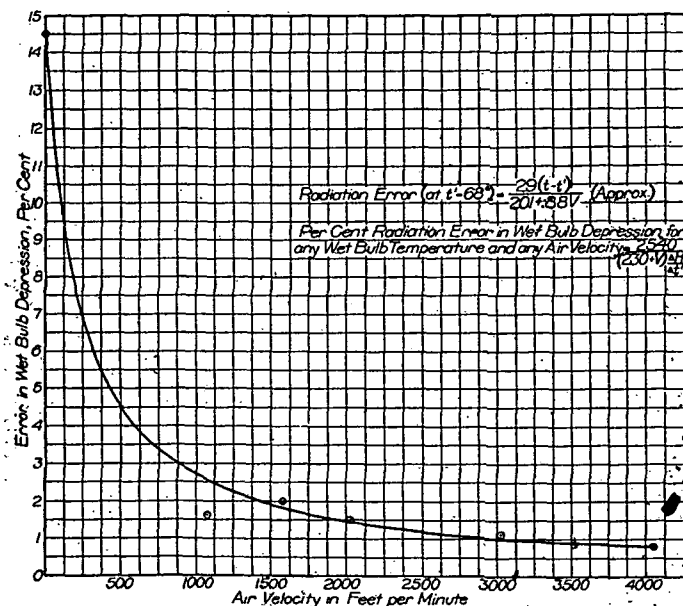


FIG. 1. ERROR IN WET BULB DEPRESSION

Variation of radiation with Variation of this Velocity over the Wet Bulb. (at $t_1 = 68$ deg. Fahr.) from experiment

as for instance, by introduction into a warmer room, the relative humidity is lowered without change of moisture content and there is an increase in the wet bulb temperature corresponding to the increase in the total heat. Thus, the temperature in a room humidified by a central station system to a definite per cent of relative humidity always bears a fixed relation to the outside wet bulb temperature.

The mathematical relation of the above physical facts involving the wet bulb depression and the weight of moisture in the air has been given and discussed by the writer in the paper presented before

The American Society of Mechanical Engineers in 1911, previously referred to. This for wet bulb temperatures above 32 deg. is as follows:

$$W = \frac{r' + C_{pa} (t - t')}{r'W' - C_{pa} (t - t')}$$

where W = the weight of moisture actually associated with one pound of dry air;

W' = the weight of moisture which would be associated with one pound of dry air in a saturated mixture at the true wet bulb temperature;

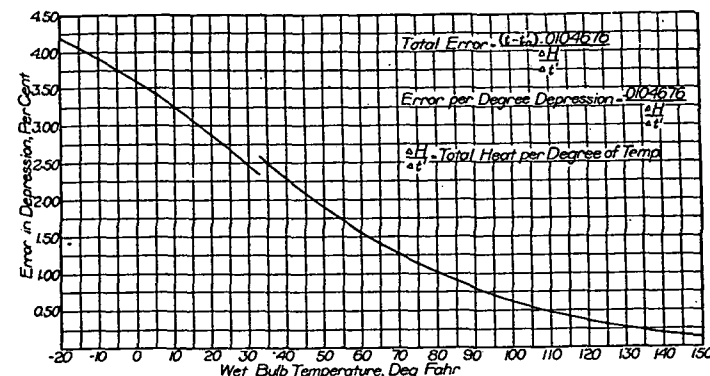


FIG. 2. AVERAGE RADIATION ERROR IN OBSERVED WET BULB DEPRESSION, IN PER CENT OF TOTAL WET BULB DEPRESSION, FOR DIFFERENT WET BULB TEMPERATURES

t = the dry bulb temperature;

t' = the true wet bulb temperature of evaporation;

r' = the latent heat per pound of water vapor corresponding to the wet bulb temperature t' ;

C_{pa} = the mean specific heat of air between the temperatures t and t' ;

C_{ps} = the mean specific heat of water vapor between the temperatures t and t' .

The numerical values of these physical units are given in Appendix.

It has previously been shown by the writer that the observed reading of the wet bulb on the ordinary sling psychrometer is always slightly higher than the true temperature of evaporation. However, the observed wet bulb depression approaches within 1.6 per cent at 2000 air velocity and within 1 per cent of 3000 air velocity

of the theoretical depression with the wet bulb temperature around 68 deg. (see Fig. 1). The writer has found that this percentage of error will increase with lower wet bulb temperatures and will decrease decidedly at higher wet bulb temperatures (see Fig. 2). This error is apparently due to three factors:—

1st, The transmission or conduction of heat of the surrounding air through the layer or film of cool air surrounding the bulb to the bulb itself;

2nd, By direct radiation from surrounding objects which will normally be at the dry bulb temperature;

3rd, Transmission through the stem of the thermometer, which, of course, is at the dry bulb temperature.

The writer has found that this error could be largely eliminated by the use of high velocities and by protecting the thermometer from radiation from warmer bodies, and also by covering the stem of the thermometer with a wicking. Thus, the error by transmission or conduction through the air itself is apparently small at the usual high air velocities at which wet bulb readings are taken.

The writer has found through a careful mathematical investigation comparing the observed depression with a theoretical depression, that the vapor pressure in the air for any given observed wet bulb and dry bulb temperature of the standard sling psychrometer by the following psychrometric formula:—

$$e = e' - \frac{(P - e')(t - t')}{2920 - \frac{69500}{80 + t_p - t'} + .0017P(t - t')}$$

This may be placed in an approximate form more convenient for calculation, as follows:—

$$e = e' - \frac{(P - e')(t - t')}{2920 - \frac{69500}{80 + t_p - t'} + (.00000022)(t - t')^2}$$

where e = the vapor pressure of the moisture actually contained in the air, i.e., the vapor pressure corresponding to the dew point;

e' = the vapor pressure corresponding to the observed wet bulb temperature, using a sling psychrometer or air velocity of approximately 2000;

P = the barometric pressure in inches of mercury;

t = the dry bulb temperature in degrees fahrenheit;

t' = the observed wet bulb temperature in degrees fahrenheit with a sling psychrometer or equivalent wet bulb thermometer;

t_p = the boiling point in degrees fahrenheit corresponding to the barometric pressure; for the standard barometric pressure (29.92), t_p equals 212 deg.

The general form of this was determined rationally in 1911. This has been carefully deduced by calculation in the plotting of curves covering all range of conditions between 32 and 180 deg. wet bulb and dry bulb temperatures up to 800 deg. fahr. and also for various barometric pressures. This is particularly valuable, as it can be applied without any corrections to observed wet bulb readings for all temperatures above 32 deg. with the probability of error less than that due to a tenth of a degree error in reading the wet bulb temperature.

The dew points obtained by this formula have been compared with the corresponding dew points as given by the U. S. Weather Bureau which were based on actual dew point observations and have been found to agree with these through their more accurate ranges, i.e., the ranges covered by a preponderance of actual observations.

This formula, which is exact for all ranges of temperature and humidity above 32 deg. and for all barometric pressures, would indicate that Professor Farrel's formula, adopted by the U. S. Weather Bureau must be inexact for extreme conditions of low humidities and for high temperatures at all humidities. It is also apparently inaccurate for low barometric pressures. Through the usual range of normal atmospheric conditions, however, the constants employed are such as apparently to give very accurate dew point determinations, when it is taken into consideration that the formula is based on a series of vapor pressures which are now known to be incorrect. Both the above formulae and the Government formula for vapor pressures are inaccurate below 32 deg. if ice is allowed to form on the wet bulb, although these formulae will apply if readings of the wet bulb are taken at the instant water on the wet bulb is sub-cooled to a minimum point below the freezing point without the formation of ice crystals. The reason that a different psychrometric equation must be used below 32 deg. wet bulb temperature is that to t' , the latent heat of water vapor at the wet bulb temperature, there must be added 144 B.t.u., which represents the additional latent heat required in the melting of ice. For the temperatures below 32 deg. the following formula is correct:

$$e = e' - \frac{(P - e')(t - t')}{3000 + 2.2P - 1.6t'}$$

In Figs. 1 and 2 are given the curves showing the probable per cent of error in the observed wet bulb depression referred to the theoretical wet bulb depression. This is what is termed the radiation error previously referred to. It will be noted that at the higher temperatures the percentage of error is exceedingly small, while at the very low temperatures the percentage of error becomes quite appreciable. The greatest error in degrees, of course, occurs in perfectly dry air. The maximum possible degrees of error in the depression is somewhat less at the lower temperatures than it is at the higher temperatures, as the per cent of error must necessarily follow the increments of total heat corresponding to the various wet bulb temperatures. Also, the maximum depressions increase somewhat faster with the temperature than do the increments of total heat.

The vapor pressures in these formulae are based on the Marks & Davis tables above 32 deg. and Professor C. F. Marvin's tables of vapor pressures below 32 deg., and these seem to be the most accurate ones available and are in perfect agreement with each other.

Maximum Absorbing Capacity of Air.—The maximum amount of moisture which a pound of air with known temperature and moisture content will absorb when brought finally to the point of saturation is given by the following formula:

$$(W' - W) = \frac{(C_{pu} + C_{ps}W)(t - t')}{r'}$$

where W = the initial weight of moisture contained in one pound of dry air;

W' = the pounds of moisture contained in one pound of dry air if saturated at the wet bulb temperature at the given barometric pressure;

C_{pu} = the specific heat of air;

C_{ps} = the specific heat of water vapor;

t = the dry bulb temperature;

t' = the wet bulb temperature;

r' = the latent heat of evaporation.

Usually at standard barometric pressure this means that each pound of air will have a maximum absorbing and evaporating capacity of one and one-half grain of moisture for each degree of wet bulb depression.

In practical application, air cannot usually be brought to complete saturation and the dryer will have a per cent of efficiency depending upon the ratio of the actual to the theoretical maximum absorption. In the commercial types of dryers this will usually

vary from 50 to 80 per cent. In many types of compartment dryers it is necessary to maintain certain definite relative humidities. In these the absorbing capacity of the air can be exactly determined, as it is the difference between the maximum absorbing capacity of the air in the dryer at known relative humidity and therefore known wet bulb depression and the theoretical moisture absorbing capacity of the air introduced.

APPLICATION OF PSYCHROMETRIC PRINCIPLES TO THE DRYING AND CONDITIONING OF MATERIALS

A very interesting and practical application of psychrometric principles is in the drying and moistening of hygroscopic materials with air. In the drying of materials two different and distinct states of the material must always be taken into consideration. In the first state there is free water present in excess of the moisture which will be normally reabsorbed by the material when subjected to a saturated water vapor or saturated air. It is in this state where most of the drying has to be accomplished. In the second condition there is only hygroscopic material present, i.e., moisture which the material will absorb of itself from more or less saturated air.

The amount of moisture which can be contained by the material in the first state is variable and is either dependent upon its porosity, as in the sponge, or upon the limits of semi-fluid consistency as in flour dough. In both cases the moisture content is to a large extent determined by previous mechanical treatment, such as pressing or centrifugal action. There is a point at which the material will contain a large percentage of free moisture which cannot be removed by any mechanical action. The free moisture in the material has a very simple physical relation to the material and is evaporated with practically the same ease that moisture would be evaporated from a free water surface, except as its diffusion may be retarded by the natural lack of porosity of the material, as for example in the drying of chicle.

The maximum regain, that is, the maximum amount of moisture which materials will hold in saturated air due to their hygroscopic properties, is a very definite quantity for each material but varies greatly with different materials. For example, at 95 per cent relative humidity, cotton will hold from 19 to 20 per cent of moisture, silk will hold from 22 to 24 per cent of moisture, while wool will hold from 26 to 27 per cent of moisture. Above this to saturation the moisture content will increase rapidly to probably from 6 to 10 per cent higher in each case.

The hygroscopic moisture in the material as distinguished from

the free moisture bears a very intimate relation to the material itself. The relation is on the border line between chemical and physical, precisely as is the case with the solution of a soluble salt in water.

It is a well known physical fact that free water, whether in a vacuum or exposed to atmosphere, generates a vapor pressure at its surface which is identical with the pressure of the saturated water vapor at the same temperature as the water. In other words, a free body of water tends to saturate the space surrounding it until the vapor tension in the space and at the surface of the water are at an equilibrium. If no heat from outside were applied, then this vapor tension at the surface of the water and the final temperature of the air and saturated vapor in the given space would be the true or theoretical wet bulb temperature.

The force producing the evaporation is the vapor pressure at the surface of the water corresponding to the water temperature. The heat to maintain this vapor pressure, however, is supplied from the air where no other source of heat is available, as in the case of the wet bulb thermometer and similar phenomena.

In insoluble hygroscopic materials the vapor tension of the water in the material is apparently the same as the vapor pressure corresponding to the temperature of the material whenever the material contains more moisture than it is capable of absorbing hygroscopically. Whenever the moisture in the material is less than the maximum possible hygroscopic moisture content, the vapor pressure of the moisture in the material is less than the vapor pressure corresponding to the temperature of the material. This apparent reduction in vapor pressure of the hygroscopic material is probably caused by the affinity of the partially saturated material for moisture.

The vapor pressure corresponding to a given constant temperature decreases in a definite manner as the content of hygroscopic moisture in the material is decreased and, of course, it increases with the increase of the moisture content up to the saturation point of the material, where it is presumably the same as the vapor pressure for free water. The vapor pressure exerted by the hygroscopic material in a given material may be conveniently expressed as a percentage of the pressure of saturated water vapor at the same temperature.

Fig. 3 gives the percentage of vapor pressure exerted by the hygroscopic moisture in American cotton at 77 deg. Fahr., according to determinations made by Schloësing. It will be seen from this that the vapor pressure increases relatively slowly with a small moisture content and also with a high moisture content, while the most rapid

increase of vapor pressure occurs at about 38 per cent of normal vapor pressure, or at about 5 parts moisture per 100 parts of dry material. This vapor pressure curve is characteristic of all hygroscopic materials, although the corresponding percentages of moisture in the material vary widely with the nature of the material.

The absolute vapor pressure of the moisture in the material is, as previously stated, dependent upon the temperature of the material, as well as upon its hygroscopic moisture content. Material that is exposed to an atmosphere having a lower vapor pressure than that of the moisture in the material, the hygroscopic moisture will tend to evaporate from the material until an equilibrium in vapor tension

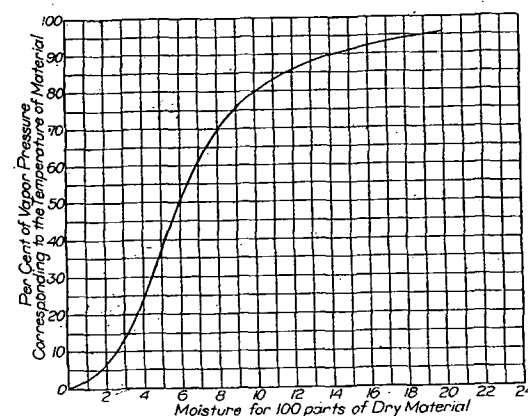


FIG. 3. VAPOR PRESSURE OF MOISTURE IN AMERICAN COTTON AT 77 DEG. FAHR.

between the moisture in the material and the moisture in the atmosphere is reached. In this process sensible heat is absorbed either from the material or the atmosphere or both and converted into latent heat of the water vapor released. Conversely, when the vapor tension in the material is lower than that of the surrounding atmosphere moisture is actually absorbed by the material from the atmosphere until the two vapor pressures are equalized. In this absorption process the water vapor is actually condensed into a liquid within the material and the latent heat of absorption is liberated, raising both the temperature of the material and of the surrounding air a corresponding amount. This is an effect often overlooked by engineers. A dry product will liberate heat very rapidly in the absorption of moisture and in some cases so rapidly as to injure the product when there is a high temperature of the saturated

atmosphere. In moistening the material air has to be supplied for removing the latent heat of absorption as well as to supply the necessary moisture.

Rate of Evaporation and Absorption.—Some years ago the writer made a series of tests to determine the laws governing the rate of evaporation from a free water surface. It was found that there were three controlling factors which determined this rate of evaporation:—

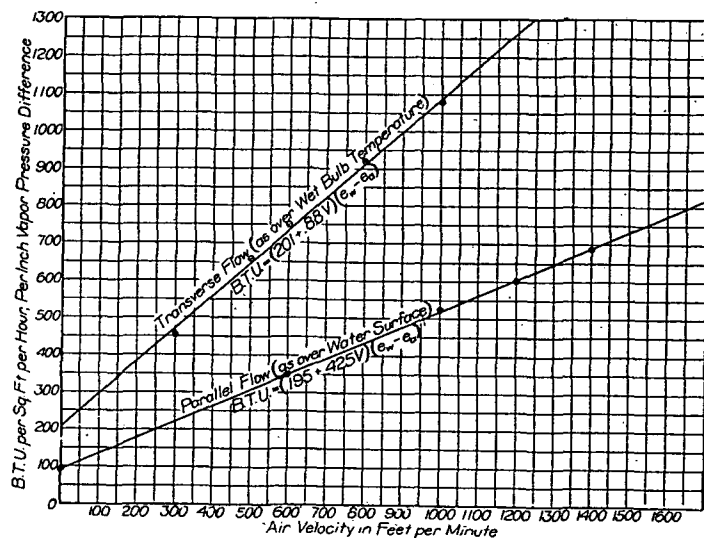


FIG. 4. CURVES SHOWING B.T.U. TRANSMISSION BY EVAPORATION FROM WATER SURFACE

With various velocities of air per inch pressure difference (mercury) in vapor pressure in air and vapor pressure of water (as determined by Carrier—1913-14)

- 1st, The vapor tension of the water corresponding to its temperature;
- 2nd, The vapor tension of the moisture in the air corresponding to its absolute moisture content or dew point temperature;
- 3rd, The effective velocity of air over the surface.

It was found that both in still air and under constant conditions of air velocity that the rate of evaporation from the surface was proportional to the difference in vapor pressure between the air and water regardless of the temperatures of the air. The evaporation from an unheated water surface at constant air velocity would be in direct proportion to the difference in vapor tensions corresponding respectively to the dew point of the air and to wet bulb temperature

of the air. It will be seen by referring to the psychrometric formula, that the difference of the vapor tensions is nearly proportional to the difference between the wet and dry bulb temperatures for all atmospheric conditions. Therefore, the rate of evaporation from an unheated water surface at a given air velocity is practically proportional to the wet bulb depression regardless of the temperature.

It was also found that for a constant difference of vapor pressures, the rate of evaporation started with a fixed minimum in still air and increased from this point in direct proportion as the air velocity was increased. The rate of evaporation from a free water surface at

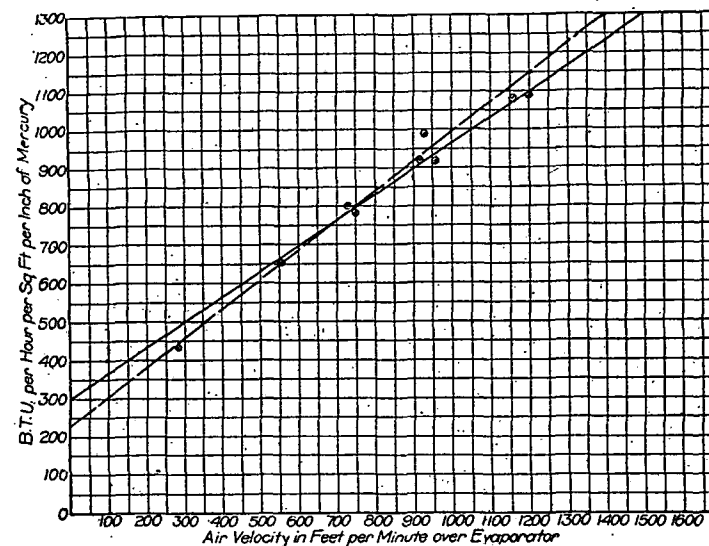


FIG. 5. HEAT TRANSMISSION BY EVAPORATION FROM SURFACE OF WET BULB EVAPORATOR (WITH TRANSVERSE FLOW)
As determined by B. H. Coffey and Geo. A. Horne, 1916

varying velocities per inch difference of vapor pressure as obtained by these experiments is shown by Fig. 4. From this it will be seen that the rate of evaporation from a free water surface with *parallel air flow* may be simply expressed numerically as follows:—

$$G = \frac{(95 + 0.425V)}{r} (e_w - e_a);$$

and with *transverse air flow* as follows:

$$G = \frac{(201 + 0.88V)}{r} (e_w - e_a) \text{ (approx.)}$$

- where G = the pounds of water evaporated per sq. ft. per hr.;
 e_w = the vapor pressure in inches of mercury corresponding to the temperature of the water;
 e_a = the vapor pressure of the moisture in the air;
 V = the longitudinal velocity of the air in feet per minute;
 r = the latent heat of evaporation.

The way the air current is applied to the surface will make a very marked difference in the coefficient of velocity.

A similar determination, although based entirely on wet bulb temperatures of the water was made by B. H. Coffey and George A. Horne (see Fig. 5). The results of these experiments were presented before The American Society of Refrigerating Engineers in 1917. The surface which they used was not a flat horizontal surface and this accounted for their getting somewhat different values from those of the writer. The writer's data, however, were most certainly well verified by the large number of tests made and the wide ranges of temperature of water used. The test was also made in air in which the temperature and humidity were automatically regulated to a constant artificial condition. This gives very good data for calculating the rates of evaporation from a free water surface with known humidity and velocity conditions of the air, and from porous materials which contain moisture in excess the maximum hygroscopic moisture content.

The above data may also be made to apply to the calculation of the rate of removal of hygroscopic moisture from material, providing that the vapor pressure corresponding to the moisture content of the material and to its temperature is known. The temperature of the wet material will remain practically at the wet bulb temperature until all of the free moisture is evaporated; then its temperature will gradually rise until the vapor pressure in the material corresponding to the vapor pressure in the surrounding air and the material is at the same temperature as the dry bulb temperature of the surrounding air.

Curve I on Fig. 6 indicates the temperature of the material of known hygroscopic quality, namely cotton, at different percentages of moisture content and subjected to a current of air having a dry bulb temperature of 100 deg. and an observed wet bulb temperature of 70 deg., with a corresponding dew point of 52.9 deg. and a vapor pressure corresponding to its moisture content of 0.4033 in. of mercury. This shows how the temperature of the material rises as the material loses its moisture content and the vapor pressure of the moisture in the material approaches the vapor pressure in the air. It is this tendency of vapor pressures to equalize that permits of

uniform drying of dense and thick materials, such as wood, pottery, etc. As the evaporation from the materials falls off to a small point owing to the free moisture from the surface having been removed, the temperature of the material tends to rise to the dry bulb temperature; then the vapor pressure of the free moisture inside the material tends to approach the vapor pressure corresponding to the dry bulb temperature of the air, which is very much higher than the

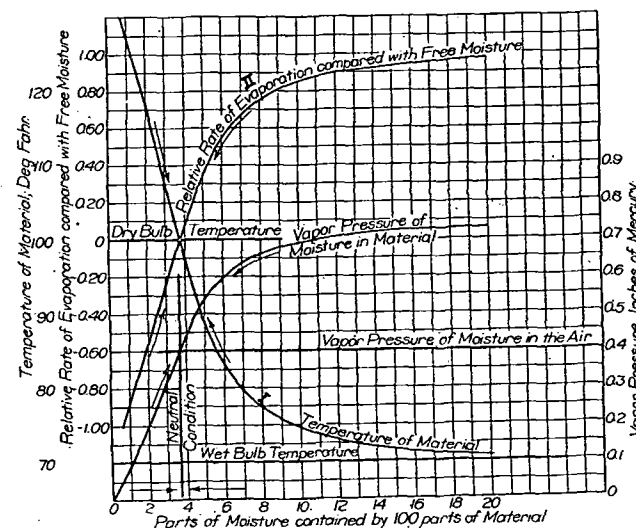


FIG. 6. EFFECT OF MOISTURE CONTENT UPON THE TEMPERATURE AND RATE OF DRYING OF MATERIAL

For American Cotton with air temperature of 100 deg. fahr. (dry bulb) and 70 deg. fahr. (wet bulb)

vapor pressure corresponding to the dew point or even than the vapor pressure corresponding to the wet bulb temperature. This is an actual pressure difference producing diffusion of water vapor and tending to re-establish the equalization of vapor pressures within and without the material.

It will be found by referring to high pressure psychrometric charts, such as those which have been prepared by the writer, that the differences of vapor pressures corresponding to dry bulb temperatures and to dew points respectively, increase very rapidly with the temperature with constant relative humidities so that the rate of diffusion of moisture through dense materials goes on many times as

rapidly at the high temperatures which are obtained in dry kilns even with high relative humidities than under conditions that obtain at normal atmospheric conditions. Practical operation of dry rooms would seem to show that diffusion of moisture is also facilitated by keeping the material in a rather moist hygroscopic state.

Curve II on Fig. 6 shows the relative rate of evaporation of hygroscopic moisture in cotton compared with the rate of evaporation with free moisture. It is interesting to note what happens at moisture contents less than that corresponding to the vapor pressure of the air. At a moisture content of 3.7 parts per hundred, the vapor pressure of the moisture in the material and the temperature are the same as that of the air and the rate of evaporation is zero. At moisture contents of material below this point, the rate of evaporation becomes negative, i.e., there is absorption of moisture. For example, the rate of absorption with material containing two parts of moisture is exactly as rapid as the drying which occurs when the material contains 6.3 parts of moisture. The temperature of the material, however, will be higher than the dry bulb temperature of the air. In this particular case it would be 118 deg., while with 6.3 parts of moisture content the temperature of the material would be 82 deg. These relations may easily be worked out for any known material and any hygroscopic condition.

The rate of evaporation, of course, will vary with the velocity exactly as it does with the free moisture surface, except where the diffusion of moisture is slower than the normal rate of evaporation. When this point is reached, increased air velocities will be of slight advantage.

The formulae by which the temperature of material and the rate of evaporation in a dry material may be calculated are as follows:—

$$t - t_m = \frac{(me_m - e)}{C'}$$

where t = the temperature of the air;

t_m = the temperature of the material;

m = the per cent of vapor pressure corresponding to the temperature and to the per cent of moisture in the material;

e_m = the vapor pressure corresponding to the saturation at the temperature t_m ;

me_m = therefore, the vapor pressure of the moisture in the material in the process of evaporation;

C = the psychrometric coefficient and is determined as follows:

$$C' = \frac{P - e'}{69500 \div 2920 - \frac{80 + t_p - t'}{t - t'}} + 0.054 (t - t')$$

The relative rate of evaporation or of absorption compared with that of a free water surface is:

$$\frac{me_m - e}{e' - e} = \frac{t - t_m}{t - t'}$$

Many hygroscopic materials are very easily injured in drying, as for example, hard wood, ceramic ware, macaroni, paper, leather, etc. It has been usual to avoid injury by slow drying, but this is not at all necessary, neither is it at all effective. Material can be injured in slow drying if the moisture conditions are not right and it is much more apt to be injured by slow drying at low temperatures without regulation than by rapid drying under properly regulated conditions.

There are two especially critical stages in the drying of all such products. The first stage is in the removal of the free moisture and a proportion of the hygroscopic moisture. This should be done at high humidities which will keep the materials pliable and prevent cracking, checking, warping or brittleness.

The next critical point in the drying is the point at which normal regain of moisture content is to be secured at the end of the process of drying. Many processes of drying injure the product by the removal of moisture far beyond the point which occurs under normal atmospheric conditions. Another point is that materials do not exhibit the proper elasticity, flexibility, appearance, etc., when dried to an excessive degree. In many cases the manufacturer loses considerable in the market value of his product owing to the fact that he is selling it at a weight which is below normal owing to the excessive removal of moisture.

It has been found possible to determine and control automatically the moisture content of hygroscopic materials to a remarkable degree of accuracy in the final stages of drying and conditioning and also to secure a perfectly uniform distribution of moisture throughout all parts of the product, which is also usually essential.

SUMMARY

It has been shown that:—

1. The psychrometric wet bulb temperature and temperature of evaporation are substantially identical.

2. In fan system tunnel dryers and in humidifiers, the wet bulb temperature remains constant throughout, while the dry bulb temperature gradually falls to the wet bulb temperature when the air becomes saturated.
3. The wet bulb temperature and temperature of evaporation are dependent simple physical relations of moisture density specific heat and density of air, and latent heat of evaporation.
4. The above relation may be conveniently expressed in simplified terms of vapor pressure, temperature and barometric pressure by two psychrometric equations, one of which holds for all temperatures and humidities above 32 deg. fahr. and for all barometrical pressures, the other for all wet bulb temperatures below 32 deg. fahr.
5. The wet bulb temperature or evaporation temperature is most important from the standpoint of air conditioning, as it determines the total heat content of the air, and any change in heat content is indicated by a corresponding change in wet bulb temperature.
6. The vapor pressure exerted by moisture in hygroscopic materials is discussed and it has been shown that the vapor pressure of hygroscopic moisture varies with the moisture content and with the temperature.
7. Experimental data has been given on the rate of evaporation from a free water surface at various air velocities and the means for calculating the same have been indicated.
8. A method for calculating the comparative rates of evaporation of hygroscopic moisture in materials has been developed.
9. The fundamental principles underlying the drying or moistening of materials with air are shown to be based on vapor pressure and upon the wet bulb temperature or temperature of evaporation.
10. In conclusion, it should be emphasized that the underlying principles and data herein given, while exact of themselves, cannot except in a few limited cases be directly applied in calculating the performance of the numerous types of dryers upon the market. These data must necessarily be supplemented by practical tests upon each type of dryer or system of air circulation. The chief value of these data is that they permit a rational interpretation of the results obtained in practice and permit very accurate determinations of the variation in results which will be secured by varying the conditions of drying, such as air velocity, temperature and humidity.

APPENDIX

The following data is used in the determination of the theoretical wet bulb or temperature of evaporation.

In the fundamental formula:

$$W = \frac{r'W' - C_{pa}(t - t')}{r' + C_{pa}(t - t')}$$

and for wet bulb temperatures below 32 deg.:

$$W = \frac{(r' + 144)W' - C_{pa}(t - t')}{(r' + 144) + C_{pa}(t - t')}$$

W' is determined from the formula:

$$W' = \frac{Se'}{P - e'}$$

where W' = the weight of water contained in 1 lb. of dry air at saturation at temperature t' ;

S = the specific weight of water vapor at the temperature t' ;

P = the barometric pressure;

e' = the vapor pressure in inches of mercury at t' .

The values of e are taken from the tables of Marks and Davis above 32 deg. and the values determined by Prof. C. F. Marvin below 32 deg. The values of S are determined from the corresponding volume tables in which the errors have been eliminated by plotting a curve. This curve gives the formula for S in terms of e as follows:

$$S = 0.6221 + 0.0015 \sqrt{e} + 0.00004445 e^{1.26}$$

The theoretical value of S is 0.6221, which has been used by the Government. It will be seen, however, that this rises considerably with the vapor pressure and temperature.

The instantaneous heat of air is

$$C_{pa} = 0.24024 + 0.000009 t \text{ deg. fahr.}$$

This is approximately the same value which the writer quoted from W. F. G. Swann (Phil. Trans. Royal Soc., series A, vol. 210, pp. 199-238, 1909) in the writer's paper before The American Society

of Mechanical Engineers in 1911. The determination of the constant, however, which was slightly lower (0.24024 instead of 0.24112) is the value obtained by Holborn in his experiments in Germany in 1913. These determinations were made with the greatest accuracy and substantially confirm the values obtained by Swann, which were considerably higher than the old value determined by Regnault of 0.2375.

The instantaneous specific heat of water vapor is taken from the approximate straight line equation for the lower degrees of

$$C_{ps} = 0.4340 + 0.0135 t \text{ deg. fahr.}$$

as determined by Langen and approved by Goodenough. Both the specific heat for steam and air were taken at a temperature corresponding to the mean between t and t' .

The value of r is taken from the tables of Marks and Davis above 32 deg. The values of r below 32 deg. are assumed to conform to the practically straight line equation for values of r below 100 deg., which is as follows:

$$r = 1091 - 0.57 t.$$

The latent heat of vaporization of ice below 32 deg. is taken as

$$r = 144, \text{ or } 1235 - 0.57 t.$$

COMPARISON OF PIPE COILS AND CAST IRON SECTIONS FOR WARMING AIR

BY JOHN R. ALLEN

THE object of this paper is to present to the designing engineer data as to the comparative effects of pipe coils or cast iron sections as types of radiation, which will be useful in laying out a ventilating system. The conclusions reached are: *first*, that the condensation in pounds per square foot per hour for both pipe coils and cast iron surfaces depends, in properly designed surfaces, upon the friction of the coil; and, *second*, that the friction of pipe coils varies as the velocity to the 1.9 power and in cast iron sections as the square.

The author gives a detailed report of his experiments with charts and tables computed from the data obtained showing the results which should be obtained from either type of surface under any specific conditions. As a result of his observations the author gives the following conclusions:

CONCLUSIONS

It will be noticed in comparing the examples for pipe coil and cast iron surfaces that similar resistance gives almost the same condensation. If the difference in temperature in both cases had been taken as 119 deg., the condensation would have been almost identically the same; it would vary in the two cases by less than 2 per cent. Velocities are, however, quite different, the cast iron surface having a velocity 11 per cent. less than the pipe coil. If this same operation is repeated for a great many different conditions for both pipe coil and cast iron surfaces, it will be found that in all cases equal frictions give almost identical condensations, while, as the friction varies as the 1.9 power of the velocity, the velocities will necessarily show considerable variation. The condensation of a coil is the measure of its heating effect and the efficiency of a coil is approximately 100 per cent. This, therefore, shows that the heating effect of a blast heater surface—properly designed—depends upon the friction of the coil and not upon the catalogue velocities, and that in properly designed coils it is better to compare various coils by their friction losses than by velocities and free air areas. For the designing engineer it would be better to assume friction in selecting a coil than to assume velocity. This being the case, it is immaterial where the free air area of a coil is taken, as the friction depends upon the volume of air passing through the coil.

It is of course possible to construct a poorly designed heater either in pipe coil or cast iron sections in which condensation will not be proportional to friction. In one case, the areas in the coils might be so open that the air could pass through the coil without being materially heated. It is also possible to construct a coil in which the friction would be excessive, in which case there would be a loss of effectiveness due to excessive eddy currents. In any coils properly designed the condensation should be proportional to the friction through the heater and were it possible to construct a perfect design of coil, this relation would be absolutely true.

In the design of ventilating systems many engineers and architects have not given sufficient attention to the friction of air passing through the heater. The results of this paper would seem to show that the friction through the heater is the most important consideration in the selection of a heater. Good practice requires that the friction of the heater should not exceed more than one-half the total pressure produced by the fan. If the heater friction is too high, excess pressure must be produced by the fan to overcome this friction, requiring additional power to drive the fan. This additional power means an extra charge which is an operating expense and must be paid throughout the whole operating life of the plant. If the friction is taken too low, then the coil becomes ineffective and a much larger coil must be used than is necessary to produce the heating effect desired. The heating resistance of the heater should be proportioned to the piping resistance or to the total pressure produced by the fan. The exact proportion that should be used has, as far as I know, only been roughly approximated.

THEORY OF HEAT LOSSES FROM PIPES BURIED DEEPLY IN THE GROUND

By JOHN R. ALLEN

THE author, realizing the small amount of information available on the subject of heat losses from pipes buried in the ground, presented a complete mathematical analysis of heat losses from such pipes, and gives partial experimental data as a check to his deductions, proving the theories advanced substantially correct. As a result of his analysis, the author draws the following conclusions:

- (a) That the heat loss from a pipe is not proportional to the external surface of the pipe. The heat loss per square foot of pipe in small pipes is very much larger than the heat loss per square foot in large pipes.
- (a) That the heat loss from a pipe is not inversely proportional to the thickness of the covering and the larger the pipe the thicker the covering that can be economically used.

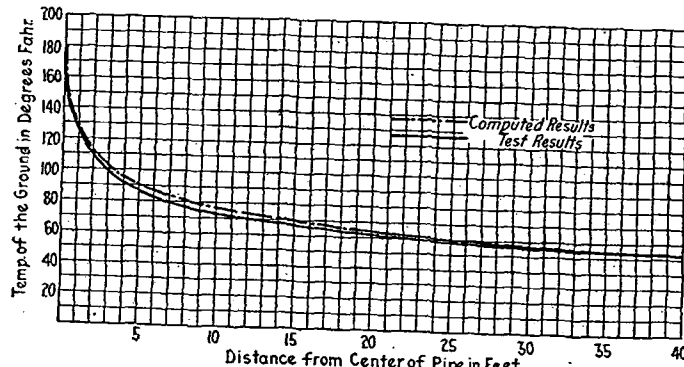


FIG. 1

- (a) That the depth to which a covered pipe is buried in the soil makes very little difference in the heat loss, provided the center of the pipe is 2 ft. or more below the ground surface. Beyond 2 ft. in depth, unless the pipes are very large, the heat loss from the pipes remains substantially the same for all depths.
- (a) That the heat loss from a pipe is not proportional to the conductivity of the covering, as the conductivity of the ground is as important a factor in the heat losses as the conductivity of the covering.
- (b) That poor covering in dry ground will give better results than good covering is wet ground. It is not possible, therefore, to guarantee the heat loss from a covering in the ground, as such a guarantee involves guaranteeing the conductivity of the ground.

As a result of the discussion which followed the presentation of this paper, the author presented another paper and added the following conclusions derived from his analysis:

First.—As the diameter of the pipe increases the desirable thickness of covering used should be increased. With small pipes, 1 in. thickness will ordinarily be all that would be economical; but with larger pipe it may be economical, depending on commercial conditions, to increase the thickness to 2 in. and over.

Second.—In multiple covering, the better covering should be placed next to the pipe and the poorer covering outside in order to insure the minimum heat transmission.

The author presents many interesting charts showing the relative effect of pipe sizes, depth of burying, thickness of covering, etc., on the heat loss.

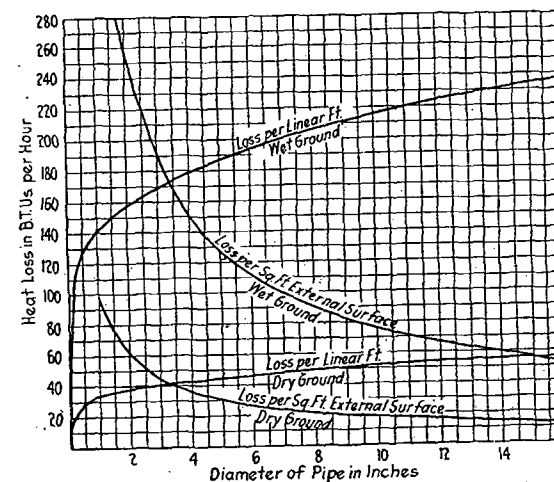


FIG. 2

Fig. 1 shows the ground temperatures at various distances from a 3 in. bare pipe buried 5 ft. 6 in. in the ground with a pipe temperature of 165 deg. fahr.

Fig. 2 illustrates the comparative effect of the pipe size on the heat loss from the bare pipes buried deeply, computed from the following equation derived by the author:

$$H = \frac{2\pi k (t_1 - t_2)}{\log \frac{r_2}{r_1}}$$

where H equals the heat loss per linear foot of pipe; t_1 , the average temperature of the ground at a point not affected by temperature of the pipe; r_1 , distance from center of pipe to point where t_1 is taken; r_2 , the radius of the pipe in feet, and k , the conductivity of the ground in B.t.u. per hr. per deg. fahr. difference of temperature per foot of thickness. k is approximately 0.2 for dry ground and 0.9 for wet ground. For the purposes of this chart, the following values were substituted in the equation:

$$t_1 = 225 \quad t_2 = 50 \quad r_2 = 40 \quad r_1 = \text{variable} \quad k = 0.89$$

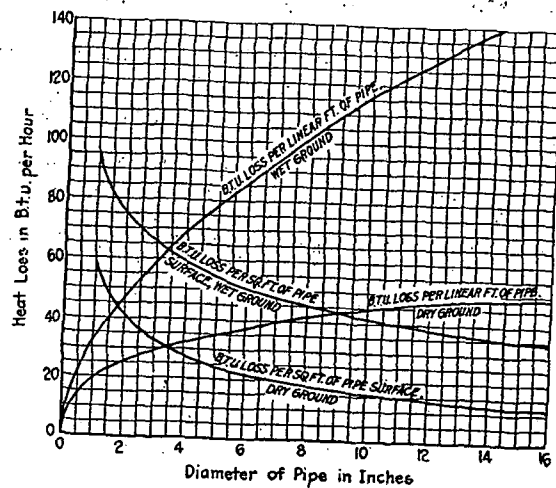


FIG. 3

In determining r_2 , the author derives the equation for any isothermal t , in the ground at the distance r which will have the temperature t .

$$t = \frac{t_1 \log \frac{r_2}{r} + t_2 \log \frac{r}{r_1}}{\log \frac{r_2}{r_1}}$$

Fig. 3 shows similar curves for a pipe covered with 1 in. infusorial earth buried deeply in the ground for steam temperature of 225 deg. fahr. with a conductivity factor of 0.04 for the covering.

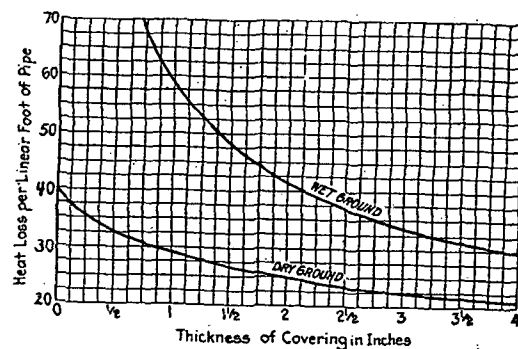


Fig. 4 shows heat losses for various thickness of covering for a 3 in. pipe buried deeply in the ground; using for the basis for calculation, $T = 225$, $K = 0.89$ for wet earth and 0.212 for dry earth and a conductivity factor of 0.04 for covering material. The curves show that for wet ground, the heat loss reduces very rapidly as the thickness of the covering increases up to 2 in. and from 2 in. up, the increase is quite gradual. For dry ground, the effect of increasing the thickness of covering, is much more gradual and above $1\frac{1}{2}$ in. it becomes almost nothing.

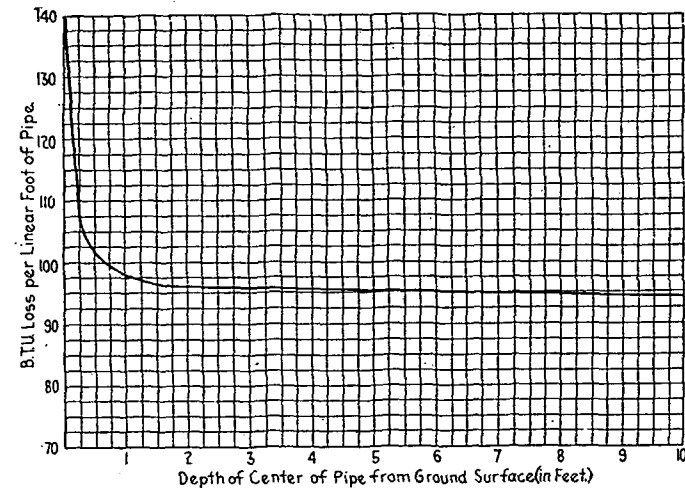


Fig. 5 shows the effect of burying pipes at different depths and shows that below 3 ft. there is little effect on the heat loss.

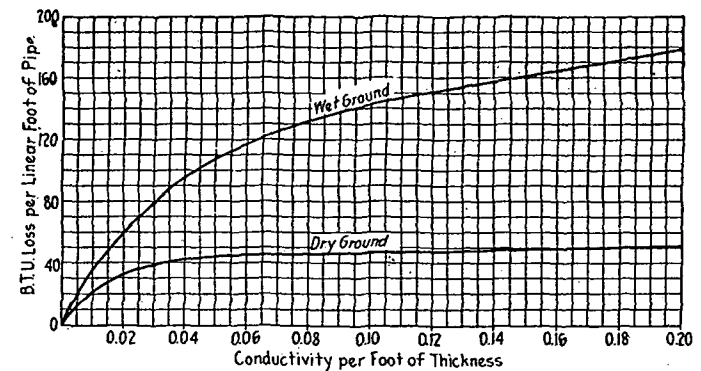


Fig. 6 shows the relation of coverings of different conductivity to the heat loss in dry and wet ground.

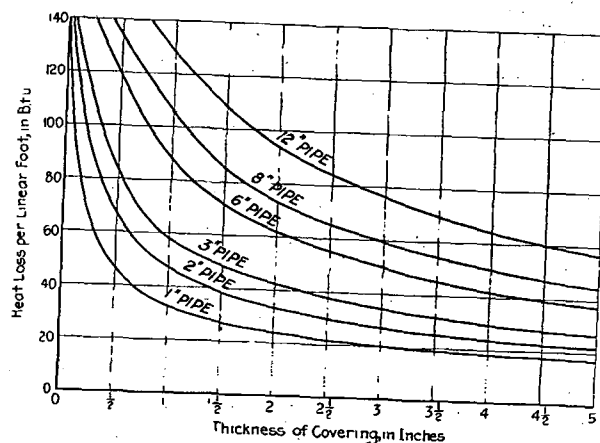


Fig. 7 shows graphically the effect of different sizes of pipe with different thicknesses of covering on the heat loss.

In the paper as presented before the Society, the author gives complete mathematical derivations for all cases and for different types of covering such as those made up of several materials and those which are made of various materials combined with air spaces.

For the complete paper (See Transactions, Volume 26, page 335, 1920).

WATER PIPE SIZES FOR PLUMBING FIXTURES, BRANCHES AND MAINS

By WALTER S. TIMMIS, NEW YORK, N. Y.

Member

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 the accompanying Table 1.

PLUMBING

TABLE 1. SUPPLY SIZES FOR FIXTURES AND MAXIMUM FLOW IN GALLONS PER MINUTE.

	Number of Fixtures									
Water Closets	1	2	4	8	12	16	24	32	40	
Gal. per min.	8	16	24	48	60	80	96	128	150	Tanks
Pipe size	$\frac{3}{4}$	$\frac{3}{4}$	1	1 $\frac{1}{4}$	1 $\frac{1}{2}$	1 $\frac{1}{2}$	2	2	2	
Gal. per min.	30	50	80	120	140	160	200	250	300	Flush
Pipe size	1	1 $\frac{1}{4}$	1 $\frac{1}{2}$	2	2	2	2 $\frac{1}{2}$	2 $\frac{1}{2}$	2 $\frac{1}{2}$	Valves
Urinals										
Gal. per min.	6	12	20	32	42	56	72	90	120	Tanks
Pipe size	$\frac{3}{4}$	$\frac{3}{4}$	1	1 $\frac{1}{4}$	1 $\frac{1}{2}$	1 $\frac{1}{2}$	2	2	2	
Gal. per min.	25	37	45	75	85	100	125	150	175	Flush
Pipe size	1	1 $\frac{1}{4}$	1 $\frac{1}{2}$	1 $\frac{1}{2}$	1 $\frac{1}{2}$	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	$\frac{3}{4}$	$\frac{3}{4}$	$\frac{3}{4}$	1	1	1 $\frac{1}{4}$	1 $\frac{1}{4}$	1 $\frac{1}{2}$	1 $\frac{1}{2}$	
Bath Tubs										
Gal. per min.	15	30	40	80	96	112	144	192	240	
Pipe size	$\frac{3}{4}$	1	1 $\frac{1}{4}$	1 $\frac{1}{2}$	2	2	2	2 $\frac{1}{2}$	2 $\frac{1}{2}$	
Shower Baths										
Gal. per min.	8	16	32	64	96	128	192	256	320	8" rain
Pipe size	$\frac{3}{4}$	$\frac{3}{4}$	1 $\frac{1}{4}$	1 $\frac{1}{2}$	2	2	2 $\frac{1}{2}$	2 $\frac{1}{2}$	3	head
Acid and Slop Sinks, Manu- facturing, Kitchen and Laundry										
Gal. per min.	15	25	40	64	84	96	120	150	200	per bibb
Pipe size	$\frac{3}{4}$	1	1 $\frac{1}{4}$	1 $\frac{1}{2}$	1 $\frac{1}{2}$	2	2	2	2 $\frac{1}{2}$	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 risers and mains.

For presentation at the Semi-Annual Meeting of the AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS, Buffalo and Detroit, June, 1922.

Water flowing in pipes is retarded by friction, the extent of which depends upon the velocity; this amount of friction is very great and 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 source of water supplies for most buildings is below the fixtures and comes from street mains which deliver water at varying pressures on various floors; the pressure necessary to raise water from the point of entry or supply to the uppermost fixture is called the static pressure, if referred to in pounds, and the amount of elevation in feet is called the static head; the total pressure needed to discharge a given quantity of water is the pressure necessary to overcome friction in the pipes (when horizontal) plus the static pressure when the discharge is higher than the supply.

Pipes may be sized for giving any desired pressure drop per 100 ft. of run by using Table 5, from 5 lb. up to 150 lb. per sq. in. (column 4), and any pipe sizes from $\frac{3}{4}$ in. to 4 in. If the length of pipe under consideration is longer or shorter than 100 ft., the pressure drop will be proportionately greater or less than the pressure drop used. For instance, if the pressure drop is 10 lb. for 100 ft. of run, it will be 20 lb. for 200 ft. and only 5 lb. for 50 ft. of length. If the total pressure drop on 300 ft. of pipe should not exceed 15 lb., use the 5 lb. per 100 ft. pressure table—see column 4 Table 5.

Table 5, 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, while column 3 gives the static head plus 15 lb. which appears to be desirable for the top floor of a building having fixtures located not more than 50 ft. away from the main riser.

The pressures shown in column 3 do not include any allowance for friction in the main riser and these values would be greater by 1 lb. for every 10 ft. on the basis of a 10 lb. pressure drop per 100 ft.

The underlying principle involved in determining the proper pipe sizes for mains, risers and branches is to so regulate the sizes 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.

The accompanying Table 1 gives the amount of water in gallons which should flow per minute for the number of fixtures indicated of each different type, together with the branch pipe size necessary to carry this amount of water with a pressure drop of 30 lb. per 100 ft. of run.

The volume of water required per fixture is reduced as the number of fixtures in each group is increased, to take care of the factor of probable use.

TABLE 2. SIZES OF WATER SUPPLY BRANCHES

Fixture	Number of Fixtures					
	1	2	4	8	12	16
Water Closet	$\frac{1}{2}$	$\frac{3}{4}$	1	1 $\frac{1}{2}$	1 $\frac{1}{2}$	1 $\frac{1}{2}$
With Tanks	1	1 $\frac{1}{2}$	1 $\frac{1}{2}$	1 $\frac{1}{2}$	2	2
With Flush Valves						
Urinals	$\frac{1}{2}$	$\frac{3}{4}$	1	1 $\frac{1}{2}$	1 $\frac{1}{2}$	1 $\frac{1}{2}$
With Tanks	1	1 $\frac{1}{2}$	1 $\frac{1}{2}$	1 $\frac{1}{2}$	1 $\frac{1}{2}$	2
With Flush Valves						
Lavatories and Washing Sinks	$\frac{1}{2}$	$\frac{3}{4}$	$\frac{3}{4}$	1	1	1 $\frac{1}{2}$
Per bibb	$\frac{1}{2}$	1	1 $\frac{1}{2}$	1 $\frac{1}{2}$	2	2
Bath Tubs	$\frac{1}{2}$	$\frac{3}{4}$	1 $\frac{1}{2}$	1 $\frac{1}{2}$	1 $\frac{1}{2}$	2
8 in. Shower	$\frac{1}{2}$	$\frac{3}{4}$	1 $\frac{1}{2}$	1 $\frac{1}{2}$	1 $\frac{1}{2}$	2
Slop and Acid, Manufacturing and Laundry Sinks, per bibb	$\frac{1}{2}$	1	1 $\frac{1}{2}$	1 $\frac{1}{2}$	1 $\frac{1}{2}$	2

TABLE 3. WATER RISERS FOR MANUFACTURING BUILDINGS, LOFT BUILDINGS, APARTMENT HOUSES, HOTELS

Estimate gallons per minute by Table 1—Table of Supply Sizes for Fixtures, and assume the amount so determined is 100 gal.

Take 60 per cent for top floor. For each lower floor add 60 per cent of its total and deduct 10 per cent of the combined floors above, down to 40 per cent but not below.

Thus:

			Pipe size with 10 lb. drop
10th floor	100 gals.	60% = 60	2"
10 & 9	200 x .60	90% = 108	2 $\frac{1}{2}$ "
10 & 9 & 8	300 x .60	80% = 144	2 $\frac{1}{2}$ "
10 to 7 incl.	400 x .60	70% = 168	3"
10 " 6 "	500 x .60	60% = 180	3"
10 " 5 "	600 x .60	50% = 180	3"
10 " 4 "	700 x .60	40% = 184	3"
10 " 3 "	800 x .60	40% = 192	3"
10 " 2 "	900 x .60	40% = 216	3"
10 " 1 "	1000 x .60	40% = 240	3"

Select from Table 5 pipe size for pressure drop selected, using preferably 10 lb. drop per 100 ft.

TABLE 4. FOR RESIDENCES

Use Table 1 and for the main supply use 25 per cent of total of gallons used by fixtures and then take pipe size from Table 5 on a basis of 10 lb. pressure drop per 100 ft. or less if water supply pressure is less than 50 lb.

The pressure drop of 30 lb. per 100 ft. of run will give satisfactory results for branches on the top floor but a higher pressure drop can be used on floors below corresponding with the pressures as given in Table 5 which show that for a building 100 ft. in height, a pressure drop of 100 lb. can be used on the fixture branches and that for a building 50 ft. in height, a pressure drop of 75 lb. can be used on the fixture branches; Table 1, however, can be used with safety on any of the floors but will give pipe sizes larger than necessary for the lower floors in a very tall building.

TABLE 5. PIPES MAY BE SIZED FOR GIVING ANY DESIRED PRESSURE DROP PER 100 FT. OF RUN

Col. 1 Vertical rise of water to fixture in ft.	Col. 2 Static pressure in per sq. in.	Col. 3 Pressure in lb. per sq. in. needed for good flow at fixture based upon 15 lb. at top floor.	Col. 4 Friction drop lb. per sq. in. per 100 ft. run.	Pipe Sizes in Inches				
				%	1	1 1/4	2	3
					Gallons Per Minute			
					5	7	10	15
0	4.33	15	5.4	11	19	30	62	109
10	8.66	20	6.4	13	23	36	74	129
20	12.99	24	7.6	15	27	43	88	154
30	17.32	28	10.8	22	38	61	125	218
40	21.65	33	13.2	27	47	76	153	267
50	25.99	37	15	31	54	86	176	308
60	30.32	41	17	35	60	96	197	345
70	34.65	46	21	43	74	117	242	423
80	38.98	50	24	49	85	136	278	485
90	43.31	54	27	55	96	152	311	544
100	47.64	59	30	60	105	166	341	598
110	51.97	63	33	66	117	184	374	655
120	56.30	67	37	75	130	203	418	722
130	60.63	71	41	100	145	224	461	790
140	64.96	76	46	125	161	247	504	858
150		80	50	150	178	271	547	926

NOTE: * This pressure as given is based upon a pressure drop of 15 lb. in a run of not more than 50 ft. which will permit the top floor branches to be sized from the table opposite of 3 lb. drop per 100 ft. of run. The pressure drop on the lower floors may be greater, as the static head increases the pressure available for branch connections. The pressures as given do not include any allowance for friction in the main riser which may be computed for any pressure drop per 100 ft. run from the table above.

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.

TABLE 6—SHOWING WATER PRESSURE REQUIRED TO DELIVER WATER TO TOP OF VERTICAL RISER WITH 15 LB. PRESSURE AT THE TOP BRANCH

Vertical rise of water from main to highest fixture branch.	Static head in lb. per sq. in.	Water pressure in lbs. required to deliver water to top of riser with 15 lb. terminal pressure.			
		5 lb.	7 lb.	10 lb.	20 lb.
0	0	15	15	15	15
10	4.33	20.5	20.7	21	22
20	8.66	25	25.4	26	28
30	12.99	29.5	30.1	31	34
40	17.32	35	35.8	37	41
50	21.65	39.5	40.5	42	47
60	25.99	44	45.2	47	53
70	30.32	49.5	50.9	53	60
80	34.65	54	55.6	58	64
90	38.98	58.5	60.3	63	72
100	43.31	64	66	69	79
110	47.64	68.5	70.7	74	85
120	51.97	73	75.4	79	91
130	56.30	77.5	80.1	84	97
140	60.63	83	85.9	90	104
150	64.96	87.5	90.5	95	110

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 5, at the pressure drop indicated.

The following examples will be given, using Table 5:

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 3 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 Table 5 from which it will be seen that on the top floor it will be necessary to use a 1 1/2 in. branch to carry 75 gal. per min. with a pressure drop of 30 lb. but that at 50 ft. vertically from the supply, a 1 1/4 in. branch pipe will carry 74 gal. per minute, therefore 1 1/4 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 5 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 3 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; the table of 5 lb. drop of Table 6 may be used, which will show that a 3 1/2 in. supply would be necessary.

Table 2 is a condensed form of Table 1, omitting the number of gallons per fixture, carrying the number of fixtures from 1 to 16.

Table 3 gives a method for computing the sizes of mains and risers and the pipe sizes given are based upon a pressure drop in the main riser of 10 lb. per 100 ft. of run; other values such as 5 lb. or 7 lb. can be used from Table 5 if it is found advisable on account of very long runs.

It will be seen that 60 per cent of the total amount of water required for all the fixtures on any floor is given as the *factor of use* and that a further reduction is made by deducting 10 per cent on each floor below the top floor until 40 per cent is reached. This of course is a matter of judgment and experience, but the volume of flow will be adequate for the average case; providing the pipe sizes selected are ample for the drop in pressure admissible.

WHEN TANK IS ON ROOF

If tank is elevated about 35 ft. above highest fixture, which would be about 25 ft. above the roof, all the computations given herein 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.

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 at forty times the diameter of the pipe approximately as follows:

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	5	8.3	10	11.7	13.3

The pressure loss due to friction in the main leading to base of riser can readily be added to the pressure required at the base of a riser, thus:

Required—the size of riser and main for a 10-story building 100 ft. high where the water use per floor as given by Table 1 for fixtures aggregates 100 gal. per floor:

The computations as given in Table 3 show that the water flow required on the various floors is as follows:

TABLE 7. GIVING EXAMPLE OF RISER SIZES FOR DIFFERENT PRESSURE DROPS

Floor	Gal. per min.	PER 100 FT. RUN			
		5 lb.	7 lb.	10 lb.	20 lb.
10	60	2	2	2	1½
9	108	2½	2½	2½	1½
8	144	3	3	2½	2
7	168	3½	3	3	2½
6	180	3½	3	3	2½
5	180	3½	3	3	2½
4	184	3½	3	3	2½
3	192	3½	3	3	2½
2	216	3½	3	3	2½
1	240	3½	3½	3	2½

If the system of mains and risers is based upon 10 lb. pressure drop per 100 ft. run, the pressure required at base of riser when water is flowing will be 69 lb., see Table 6 at 100 ft. height; or at 20 lb. drop it would be 79 lb. while at 5 lb. drop it would only be 64 lb.

Pressure required at the main 100 ft. away with 10 lb. drop per 100 ft. would be $69 + 10 = 79$ lb. or 50 ft. away $69 + 5 = 74$ lb.

WATER SUPPLY FORMULA

CF = Cu. ft. per min. discharged

G = Gal. per min. discharged

H = Friction head of water in feet = pressure $\times 2.31$; 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.

$$CF = 0.16 \sqrt{\frac{(3d)^5 \times 3H}{L}} \quad (1)$$

$$G = 1.2 \sqrt{\frac{(3d)^5 \times 3H}{L}} \quad (2)$$

$$H = \frac{(0.16 \times CF)^2 \times L}{(3d)^5} \quad (3)$$

$$H = \frac{(1.2G)^2 \times L}{(3d)^5} \quad (4)$$

The above formula neglect the head due to entry, which need not be computed except when L is very short.

H_1 = head due to entry in feet.

$$H_1 = \left(\frac{0.83G}{d^2 \times 13} \right)^2 \quad \text{or} \quad H_1 = \left(\frac{0.16CF}{d^2 \times 13} \right)^2$$

Example—

Required the discharge of a 2 in. main with pressure 30 lb. 100 ft. horizontal run and 30 ft. vertical run.

$$H = 30 \times 2.31 - 30 = 39.3$$

$$\text{Formula (2)} \quad G = 1.2 \sqrt{\frac{(3 \times 2)^5 \times 3 \times 39.3}{100 + 30}} = 100.8$$

In the above case the head due to entry would be

$$H_1 = \left(\frac{0.83 \times 100.8}{2 \times 2 \times 13} \right)^2 = 2.56 \text{ ft.}$$

Usually this can be neglected except for very close calculations.

RECENT DEVELOPMENTS IN WARM AIR FURNACE HEATING

BY F. R. STILL, DETROIT, MICH.

Member

SOME years ago the furnace manufacturers formed an organization known as the *National Warm Air Heating & Ventilating Association*. In 1918 this association entered into an agreement with the University of Illinois to have the latter conduct experiments on warm air furnaces. The University has rendered three reports in bulletin form known as Nos. 112, 117 and 120. The last report, which was presented to the meeting of the association at Cleveland, April 19-20, 1922, has not yet been published. The work so far completed at the University has made available a wealth of valuable data which never before was obtainable. With this data in hand it is now possible to calculate the size and performance of a furnace with about the same degree of accuracy as the size and performance of a steam or hot water boiler can be determined. The unfortunate part, however, is that very few of those who have access to the reports know how to make practical use of the data given in them and these reports have been confined almost entirely to the members of the furnace manufacturers association, who have made no effort to see that they are distributed among their agents and dealers so that they could take advantage of their practical value should they be so inclined.

Like our own Society, this association has a Warm Air Furnace Code Committee which has been struggling long and arduously in an endeavor to reconcile all the elements so as to get them to agree on a standard code. This committee submitted a report at the last meeting and a code was adopted. It is not perfect any more than was the first report on the boiler code, which was submitted to our Society, but it is a step in the right direction; is founded on the right principles and can be modified and amended at subsequent meetings. Beyond a doubt it will eventually be perfected when all the members of the association become more familiar with it and understand the benefits to be derived by having a standard which is followed by everybody.

For presentation at the Semi-Annual Meeting of AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS, Buffalo and Detroit, June, 1922.

The formula adopted in the code for determining the size of the leaders, or pipes from the furnace to the various flues and registers was devised by P. J. Dougherty, engineer of the International Heater Co., a member of our Society and also on the Research Committee of the association referred to previously. It is very simple and is based on experimental engineering data taken from the report issued by the University of Illinois. It has been checked by application to certain test problems covering quite a wide range of capacities and it has been found accurate, conservative and reliable.

The rule proposed by Mr. Dougherty is based on the following:

Outside temperature zero deg. fahr.
Inside temperature 70 deg. fahr.
Heat loss per hour per
sq. ft. of exposed wall
surface of ordinary
frame construction ... 25 B.t.u. ($0.36 \times 70 = 25.2$ B.t.u.)
Heat loss per sq. ft. of
glass per hour 83 B.t.u. ($1.18 \times 70 = 82.6$ B.t.u.)
Heat loss per cu. ft. air
space in a room, allow-
ing one air change
per hour 1.25 B.t.u. ($0.075 \times 0.238 \times 70 = 1.25$ B.t.u.)

If 1000 is divided by each of the factors, the result will give the square feet of wall surface, the square feet of glass surface, and the cubic feet of space, respectively, to equal 1000 B.t.u. loss per hour.

For example, $\frac{1000}{25} = 40$ sq. ft. of wall surface per M. B.t.u.
 $\frac{1000}{83} = 12$ sq. ft. of glass surface per M. B.t.u.
 $\frac{1000}{1.25} = 800$ cu. ft. of space in a room per M. B.t.u.

Suppose a room 10 x 12 ft. and 9 ft. high, has 2 windows, each about 16 sq. ft. area. If two of the 10 ft. walls have outside exposure and only one of the 12 ft. walls is so exposed, then the wall exposure will be $10 \times 9 \times 2$ ft., or 180 sq. ft., plus 12×9 ft., or 108 sq. ft. which equals 288 sq. ft. Subtracting 32 sq. ft. for the 2 windows, leaves a net wall area of 256 sq. ft. A room 10 x 12 x 9 ft. contains 1080 cu. ft. of space.

By dividing each of these quantities by their corresponding factors, as shown above, the result will be the heat units required in thousands; all three should be added together to get the total heat required for the room. This can be stated more clearly as follows:

$$\frac{256}{40} + \frac{32}{12} + \frac{1080}{800} = 10.41 \text{ or } 10,410 \text{ B.t.u.}$$

In order to determine what size the leader or pipe should be from the furnace to this room, consult Fig. 1, which is a duplication of the chart.

given on page 24 of Bulletin No. 120, published by the University of Illinois, and it is found that at a temperature of about 195 deg. there was obtained 125 heat units per sq. in. of leader per hour to the first story. Hence dividing 1,000 by 125 will give us 8 sq. in. per 1,000 heat units.

Therefore $10.4 \times 8 = 83.28$ sq. in. area of pipes or leaders to the room if it is on the first floor. This is about the area of a pipe 10 in. in diameter.

If the same temperature of 195 deg. is assumed for determining the second and third story pipes or leaders, the area of them should be respectively 5 sq. in. to the second story and 4 sq. in. to the third story, per thousand heat units exposure. Thus, for a similar room on the

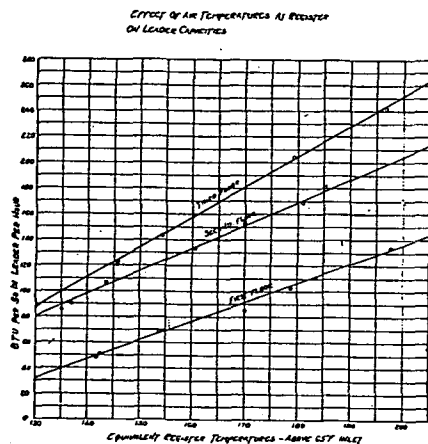


FIG. 1. CHART FOR DETERMINING LEADER PIPE SIZES

second floor, the area of the pipes would be 52 sq. in. or an 8 in. diameter pipe to the second story, and 41.64 sq. in. or a 7 in. diameter pipe to the third story.

It was decided by the Committee to allow 6 sq. in. to the second story, and 5 sq. in. to the third story, which is equivalent to a temperature of about 176 deg. Thus, the pipe to the second story would be 9 in. diameter, and to the third story 8 in. diameter. Undoubtedly, the code will be amended so as to provide for a lower temperature to the first story, the same as has been provided for the second and third. This will mean allowing 9 sq. in. per thousand heat units, or 93.6 sq. in. in the leader pipe, or 11 in. diameter instead of 10 in. as the present code provides in the foregoing example.

Reducing the allowable temperature from 195 deg. to 176 deg. evidently increases the area of the leaders to the first story more than 20 per cent above what is now the average practice, but it will avoid the necessity for maintaining such high temperatures to get sufficient heat, will be conducive to economy, and will avoid so many unsatisfactory plants.

In everyday practice when calculating the size of the leaders to the various rooms in the building, one would proceed about as follows:

$$\begin{aligned} \text{Wall } 10 \text{ ft.} + 10 \text{ ft.} + 12 \text{ ft.} \times 9 \text{ ft.} &= 288 \text{ sq. ft.} \\ \text{Glass } 16 \text{ sq. ft.} \times 2 &= 32 \text{ sq. ft.} = G. \end{aligned}$$

$$\begin{aligned} \text{Net wall surface} &= 256 \text{ sq. ft.} = W. \\ 10 \text{ ft.} \times 12 \text{ ft.} \times 9 \text{ ft.} &= 1080 \text{ cu. ft. space} = C. \end{aligned}$$

$$C = 1080 \div 800 = 1.35 \text{ M. B.t.u.}$$

$$W = 256 \div 400 = 6.40 \text{ M. B.t.u.}$$

$$G = 32 \div 12 = 2.66 \text{ M. B.t.u.}$$

$$\begin{aligned} (\text{Heat units in thousands}) \quad 10.41 \times 8 &= 83.28 \text{ sq. in.} = 10 \text{ in. dia. 1st floor} \\ 10.41 \times 6 &= 62.46 \text{ sq. in.} = 9 \text{ in. dia. 2nd floor} \\ 10.41 \times 5 &= 52.05 \text{ sq. in.} = 8 \text{ in. dia. 3rd floor} \end{aligned}$$

Should it be the reader's opinion that an air change $1\frac{1}{2}$ times per hr. should be provided for, instead of 1 air change per hour, then substitute 600 in place of the factor 800; or if it is thought that 2 air changes per hour should be allowed because of unusual exposure to high winds, or the frequent opening of doors, or because of poor construction, then use 400 in place of 800.

It is seldom that a contractor will undertake to connect a leader from a furnace to a sun-room and agree to heat it to the same comfortable temperature as any other room in the house. This is probably due to two reasons, one being that the sun-room usually is at a very considerable distance from the furnace and the other reason is due to the unsatisfactory results he has obtained in his efforts to heat such a room. This latter has likely been caused by the fact that he has never realized that fully one-third more capacity would be required in the leader pipes than would be required for a similar room of usual construction.

As an example; consider a room of the same size as in the previous case, but one that has 160 sq. ft. of glass instead of 32 sq. ft. as before, and owing to this large glass exposure 2 air changes per min. will have to be provided for; the size of the leaders would then be as follows:

$$\begin{aligned} \text{Total wall surface} &= 288 \text{ sq. ft.} \\ \text{Total glass surface} &= 160 \text{ sq. ft.} \end{aligned}$$

$$\text{Net wall surface} = 128 \text{ sq. ft.}$$

$$\text{Cu. ft. space} = 1080$$

$$1080 \div 400 = 2.70$$

$$128 \div 40 = 3.20$$

$$160 \div 12 = 13.33$$

$$19.23 \times 8 = 153.84 \text{ sq. in.} = 14 \text{ in. dia. pipe}$$

$$19.23 \times 6 = 115.38 \text{ sq. in.} = 12 \text{ in. dia. pipe}$$

$$19.23 \times 5 = 96.15 \text{ sq. in.} = 11 \text{ in. dia. pipe}$$

It will be noted that the area of the leaders is almost double the size required in the previous instance.

One phase of the furnace business, which has not yet been reported on by the University, but which has a very important bearing on the satisfactory operation of furnaces, is the size of the flues in the walls for conveying the heat to the upper stories. The Code Committee made practically no recommendations on this point at all.

The average wall in houses heated by furnaces is framed with studs known commercially as 2 x 4's; they are more often 1 7/8 in. x 3 3/4 in. and are usually spaced 16 in. centers. Thus the maximum space for a sheet metal flue is 3 3/4 in. x 14 1/2 in.; therefore, it is hardly practical to figure on a flue being more than 3 1/2 in. deep x 13 3/4 in. wide and experience shows the standard maximum width to be about 13 in.

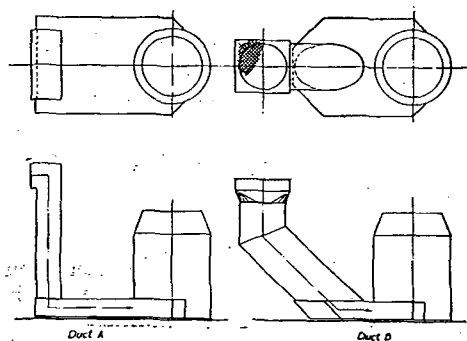


FIG. 2. TWO TYPES OF RECIRCULATING DUCTS CHANGE FROM "A" TO "B" WILL SHOW SURPRISING RESULTS

A round pipe offering the same friction for the same capacity as a rectangular duct of the above dimensions, would be 7 1/8 in. in diameter or it would have an equivalent area of 40 sq. in., whereas it has an actual area of 48.25 sq. in. Many are the instances where an 8 in. or a 9 in. leader is carried from the furnace to a riser of no greater dimensions than above mentioned, which only has the carrying capacity of a 7 in. round pipe. It is no wonder that it is so often difficult to heat rooms in the upper stories of buildings under these circumstances.

The way to overcome this, is to insist that all walls carrying warm air flues are to be built of studs not less than 2 in. x 6 in. spaced 20 in. centers. If 6 in. studs are used in such partitions or walls, even though the studs are set 16 in. centers, which is unnecessary, then a flue measuring 5 1/2 x 13 in. could be built which is equivalent to 8 1/4 in. diameter pipe. When the studs are spaced 20 in. centers then a flue 5 1/2 x 17 in. can be built in, which is equivalent to a round pipe 10 in. diameter in carrying capacity.

In Bulletin No. 120, issued by the University of Illinois, is a chart on page 21 which is herein reproduced in Fig. 3. By means of this chart the size of the furnace can be readily determined, also the amount of the fuel to be burned, the draft necessary to burn that amount of fuel, the maximum temperature attainable, the heating capacity and the overall efficiency.

As previously stated, the code as adopted, makes it necessary to carry a temperature of 195 deg. in order that the required amount of heat is supplied to first story rooms, when the leaders are determined by allowing only 8 sq. in. of area to each 1,000 heat units of exposure in the building.

Comparing the effect this high temperature has, as compared with what would be the result if only 176 deg. had to be attained, it is found that the rate of combustion must be 6.75 lb. of coal per sq. ft. of grate surface per hour. This will necessitate a draft of 0.085 in. The heating capacity of the furnace is 140,000 B.t.u. per hour, and the overall efficiency will be 56 per cent.

At 176 deg., the rate of combustion will be only 5.5 lb. per sq. ft. of grate surface per hour. The draft need only be 0.07 in.; the heating capacity is 120,000 B.t.u. per hour and the overall efficiency will be increased to 60 per cent.

Assume a house has a total exposure of 120,000 B.t.u. and compare the operating results at the two temperatures, first determining the requirements for 195 deg.

$$\frac{120,000}{0.56 \times 12,000 \times 6.75} = 2.66 \text{ sq. ft. of grate surface, or } 22.10 \text{ in. diameter.}$$

Heating 1 lb. of air from 65 deg. to 195 deg., or through 130 deg. will require 31 heat units; therefore, 120,000 heat units exposure will require 3,870 lb. of air per hour or about 860 cu. ft. per minute at 70 deg. temperature.

For 176 deg. temperature the following results are obtained:

$$\frac{120,000}{0.60 \times 12,000 \times 5.5} = 3.03 \text{ sq. ft. of grate surface, or } 23.6 \text{ in. diameter.}$$

Heating one pound of air from 65 deg. to 176 deg., or through 111 deg., will require 26.4 heat units; thus, 4,550 lb. of air per hour must be heated, or about 1,000 cu. ft. of air per minute.

In the first case the coal burned will amount to 17.86 lb. per hour; in the second, 16 2/3 lb. per hour. From this it will be noted that the rate of combustion is about 23 per cent higher to get the high temperature, and the coal consumed to give off the same amount of heat is 7 per cent more.

The volume of air at high temperature is less by about 14 per cent, hence smaller pipes are required. The grate area is about 7 per cent more for the lower temperature; in other words, the furnace having a larger grate surface would proportionately have more heating surface; thus, the same transmission could be effected at lower temperatures, by the circulation of more air, requiring less coal and still have a reserve

capacity for quick heating by running the temperature up higher, which would not be possible with the smaller outfit, which is already working at about its maximum capacity.

At Urbana it was found that by making the return air duct to the furnace the same size, or even larger than the combined area of all the leaders, and at the same time avoiding abrupt or right angle turns in this duct, that the capacity of the furnace can be increased as much as 50 per cent. It was further demonstrated that the furnace is affected much more by any restriction to the flow of air in the recirculating duct, than by a similar restriction in the leaders from the furnace to the registers.

One frequently finds installations where there are two or more recirculating ducts leading back to one furnace. This generally fails to give

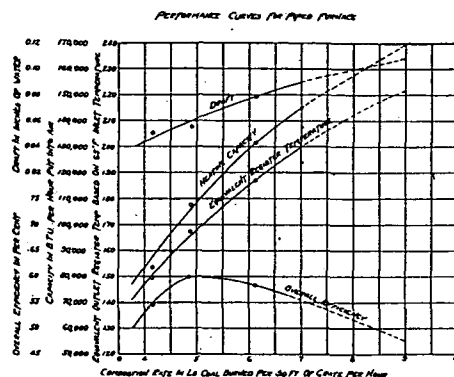


FIG. 3. CHART WILL GIVE FURNACE SIZE, FUEL AND DRAFT NEEDED, TEMPERATURE ATTAINABLE, HEATING CAPACITY AND OVERALL EFFICIENCY

as good results as one duct. It is perfectly obvious why this should be so. For example, one duct 32 in. dia., has about 8 per cent less area than would two 23 in. ducts, yet the total circumference of the two 23 in. pipes is 44 per cent more than the one 32 in. pipe; hence, for a similar length the two pipes present 44 per cent more frictional surface.

One frequently settles on the area to have and because it may be easier to install, uses a rectangular duct instead of a round one. At Urbana there was an opening $17 \times 47\frac{1}{2}$ in. behind a register face, with a right angle elbow to a vertical riser of the same dimensions, the lower end of which connected to a horizontal duct 12×67 in., the opposite end of which was attached to the base of the furnace. This is indicated in Fig. 2 as shown by A at the left. The modified recirculating duct is indicated by B on the right.

Both of the above ducts are exactly the area of a 32 in. round pipe, but the drop leg is only equal to a pipe 30.6 in. in diameter as a conductor of air, owing to the shape of it, and the horizontal leg is only equal to a pipe 29.2 in. diameter for the same reason. In other words,

the latter can only convey 83 per cent of the air that a 32 in. round pipe will convey because of the additional friction, when both have the same pressure head. Besides this, the right angle elbow alone presents an amount of resistance equal to 12 ft. of straight pipe $17 \times 47\frac{1}{2}$ in. in size, and the right angle at the base will add as much more. In view of all this, is it surprising that the capacity of a furnace can be increased 50 per cent by a few changes in the recirculating duct? Hardly anyone would knowingly set out to install a recirculating duct measuring $17 \times 47\frac{1}{2}$ in. that would be nearly 50 ft. in length with a standard register

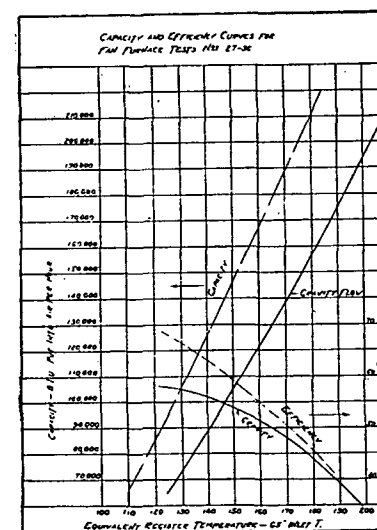


FIG. 4. CHART SHOWS COMPARATIVE RESULTS OF FURNACE TESTED WITH FORCED AND GRAVITY CIRCULATION

face on the opposite end of it. He would at least feel very uncertain of the results he would get, yet that is exactly what the resistance amounts to in the installation as it was first put in Urbana and it was in no way unusual, as it is being unconsciously done every day. The restrictions in the recirculating duct and the limited area of the flues in the walls are accountable for many of the poor results obtained from furnace installations. That a furnace fails to perform satisfactorily is by no means an accident. When one knows what its limitations are and then sees what is sometimes attempted, it seems like an accident if a furnace works at all.

SOME FACTS ABOUT CIRCULATION STIMULATORS

When the occupant of a house finds it impossible to heat his place, he does a little experimenting on his own account, he then calls in the furnaceman who does some more, usually without producing any marked

effect on the job. Finally somebody suggests that "the only way to make this job work is to put in a blower." *Usually that is the wrong way to go about it.*

Installing a blower for no other purpose than to overcome a defect by force, is an *extravagance*. Rightly applied, a blower will effect economies that cannot be duplicated in any other way, and they are not recommended for any other purpose.

Applying a blower to a furnace, should be for no other purpose than to remove the film of air in immediate contact with the heating surface more rapidly than it can be moved by gravity. As the film of air becomes heated, it carries away heat from the heating surface as it moves forward, and the more rapidly it moves, the faster the heat is removed because of a continuous film of cool air coming in contact with the hot surfaces. The capacity of a furnace which is operating under the most

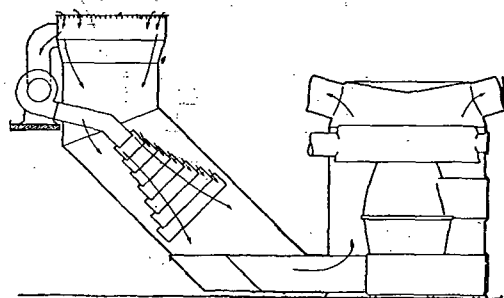


FIG. 5. DEVICE TO STIMULATE FLOW OF AIR FROM FURNACE

favorable conditions, can be increased from two to three times by using a blower. At Urbana this was demonstrated after alterations were made which had already increased the capacity by gravity circulation 1.8 times.

With a limited height of chimney and a reasonable limit to the flue gas temperature, the draft is fixed within rather narrow limits. The amount of draft fixes the rate of combustion, and the rate of combustion fixes the amount of heat obtainable from the fuel per unit of grate area. Therefore, with a fixed ratio of heating surface to grate surface, when the maximum heat transmission from a given amount of heating surface has been reached by gravity circulation, the only way to get more heat is to increase the air movement over the surface, by a blower device of some kind, or install a larger furnace with larger flues, etc.

The available pressure head is so slight in gravity work, that it needs but little resistance to stop the flow and sometimes completely reverse it. It does not require much additional pressure in many cases to set the air in motion and as soon as the ducts and flues become thoroughly heated, they will continue to operate satisfactorily.

Wherever long horizontal or crooked ducts prevail, a blower must be installed which is large enough to handle all the air that will be required to convey the maximum amount of heat into the building. Unless one is

prepared to have such a blower operate continuously when heat is required, he may be disappointed in the results, as it becomes rather costly to pay for electric current as well as coal for continuous operation.

The reason why such a blower must operate continuously and not occasionally, as a circulator can be operated, is this: Some of the leaders offer very little resistance to the flow of air, whereas some of the others offer a great deal. Therefore, dampers must be inserted in such leaders offering but little resistance, so as to make them equal the resistance of the others. If this is not done, the bulk of the air will blow through the leaders having the least resistance, with the result that little would be gained in the delivery of more air or more heat to those rooms requiring a greater amount.

By making such adjustments of the dampers to equalize the flow, it introduces so much resistance to the whole plant that the furnace is unable to heat any part of it by gravity circulation alone. That is why the blower has to run all the time, when one is installed with the expectation that all of the air required by the building will have to pass through it.

All kinds of devices have been developed to stimulate the flow of air from furnaces without having to handle all the air required to properly heat a building. Many of such devices have long since passed out of existence, and have been forgotten. During the past two years, a new crop has sprung up, one of which, Fig. 5, was recently tested at the University of Illinois and reported to the last meeting of the *National Warm Air Heating & Ventilating Association*.

This particular device is intended to make it possible to heat a building by circulating air at low temperature instead of at high temperature, thus avoiding hard firing with its inevitable waste, repairs and renewals to the furnace. Higher efficiency can be obtained under all weather and operating conditions and less attention will be demanded by the furnace to get satisfactory results.

Tests made on this device show that at a register temperature of 120 deg. it is possible to induce 60 per cent more air to flow than by gravity and at the same time get an overall efficiency 20 per cent higher. As the register temperature rises, the gain becomes gradually less; thus, at 180 deg., the amount of air induced to flow over and above what would flow by gravity is 35 per cent more and the overall efficiency is but 3 per cent more. Please bear in mind that this gain was effected after alterations had been made in the furnace so as to get the best possible results by gravity circulation. The comparative results obtainable are shown in Fig. 4.

This circulator was designed to induce the flow of several times the volume of air that the blower of itself will handle. It, therefore, consumes so little current that the cost of the fuel and the electricity combined, even if the circulator is run continuously, amounts to less than the fuel alone would amount to when similar results are produced, if such a thing could be effected.

It offers no obstruction to the flow of air in the recirculating pipe, so that the furnace can be operated without the blower running just the same as though nothing was there, and the result will in no way be different. When more heat is wanted, the circulator can be started, and

without opening the drafts, the same volume of heated air can be obtained as can be obtained by gravity at temperatures 60 to 80 deg. higher. If the same velocity could be produced by gravity as with the circulator at low temperatures, this device would be unnecessary. The only other way to accomplish corresponding results, would be to make the leaders large enough to convey the required volume at the low temperatures. In most cases this would be impracticable for lack of space, and besides, the efficiency of a furnace falls off so rapidly under such conditions that nothing like the same economy could be attained as with the circulator.

Some day circulators of some kind will be considered as necessary as any other part of a furnace plant. They will not be looked upon as something to fall back upon to make a defective plant acceptable, but they will be considered as an economical necessity, by means of which air can be circulated at more healthful temperatures, regardless of weather conditions.

The work done by Professor Willard and his staff at the University of Illinois, under the direction of the *National Warm Air Heating & Ventilating Association*, is a wonderful accomplishment. It means more to the future success of the furnace business than most of those who have had direction of this work fully realize. In the adoption of the code, herein referred to, a foundation has been laid for progress and improvement. As previously stated, the code is not perfect, but with a good foundation on which to build in the future, amendments can be made to correct and improve the code as progress and further knowledge seems to indicate.

Better furnaces will undoubtedly be designed, as they are certainly needed. None of the furnaces on the market are what would be considered a first-class design for a convector. Too much of the heat generated in a furnace is now wasted by radiation. There is no reason why a furnace cannot be designed which will show an efficiency ranging between 80 and 90 per cent. There is no furnace on the market today which will show better than about 60 per cent.

It is estimated that there are about 10,000,000 homes without furnaces in this country in climates where heat is necessary, and it is also estimated that 80 per cent, or 8,000,000, of these homes could be equipped with furnaces so that if this business could be developed it would amount to over two billion dollars, not including replacements. Thus one gets an idea of the importance of the work being done to standardize furnace practice. It has been further estimated that if those who have inefficient and ancient equipment could be induced to install modern furnaces it would be sufficient to keep the present industry busy for five years.

Owing to the poor success so frequently attending the installation of warm-air furnaces in homes of moderate size the furnace business has gradually gotten down to the stiffest kind of competition and about the only thing that recommends it to the average man is its low cost in comparison with steam or hot-water heat. Undoubtedly if it is put on a more scientific basis better installations will be the result and the public will gather confidence and will be willing to pay more money for a properly installed furnace, as it has many attractive features to recommend it. In some classes of buildings it is preferred to the complicated steam or hot-water systems and the expense necessary to install this type of apparatus.

GENERAL DATA SECTION

IN order to supply the demand for reliable practical data which might be considered as good practice for the design and construction of heating installations, this section has been added to the Guide. It has not been found practicable to include in this issue complete data covering every phase of the heating and ventilating art, but further data on various subjects will be compiled in subsequent issues.

The information here presented is the most reliable which it has been possible to obtain up to the time of going to press, and while it is not published as being absolutely accurate, in later issues this data will be revised and approved as being accurate, as rapidly as the Research Laboratory of the Society can complete investigations of the various Subjects.

The data herein contained were compiled from many different sources, and with the assistance and co-operation of many firms and individuals, who have given liberally of their time, their experience and their private data in order that this information might be made available to the industry at large. To all of these the *Guide Publication Committee* acknowledges its indebtedness and expresses its appreciation.

HEATING

HEAT LOSSES FROM BUILDINGS

IN the planning of a heating installation consideration must necessarily be given first to the heat losses which the heating apparatus must overcome. For convenience this loss is determined in heat units in terms of B. t. u. lost per hour.

Heat losses from buildings can be classified as those due to the leakage of cold air into and warm air out of the building, commonly termed infiltration, and those due to transmission through the building material enclosing the building or space termed transmission losses. The total heat loss or amount of heat which the equipment must furnish is the sum of the infiltration and transmission losses plus an allowance, which should be made for exposure.

INFILTRATION

It has been quite common practice to estimate the infiltration of air into a building in terms of the number of air changes or number of times the air which leaks in displaces the air in the room per hour. The air changes are dependent upon the tightness of the building construction, the lineal feet of window and door cracks, the amount of air admitted for ventilation and the air admitted by the opening and closing of doors, or other openings. Air changes as usually encountered in practice are as follows:

AIR CHANGES PER HOUR COMMONLY USED IN VARIOUS TYPES OF BUILDINGS

Space	Air Changes	Space	Air Changes
Halls, 1st Floor	2 to 3	Bath and Serving Rooms.	2
Halls, 2nd Floor	1	Kitchen and Offices.....	1 to 2
Halls, Living Room.....	2 to 3	Drug Stores	2 to 3
Living Rooms	1 to 2	Clothing Stores	1
Living Rooms with fire-places without damper.	2 to 4	Churches and Assembly Rooms	1 to 2
Dining Rooms	1 to 2	Factories, Lofts, Etc....	1 to 2
Sleeping Rooms	1		

Approximately 0.02 B. t. u. is required to heat 1 cu. ft. of air 1 deg. at 0 deg. fahr. Therefore, in order to obtain the loss due to infiltration, multiply the cubical contents of the room by the difference in temperature between the inside and outside (for which the system is designed) and then by 0.02.

Instead of assuming a certain number of air changes as a basis for estimating infiltration losses many engineers use the lineal feet of window and outside door cracks, thereby avoiding errors where the glass area is large or small in proportion to the cubical contents. Where the glass and door area is small in proportion to the cubical contents the loss should be checked with the air change method, so that a minimum equivalent to one air change is allowed. This is necessary in order that sufficient heat will be available to bring the room quickly up to temperature after it has been cooled down.

APPROXIMATE HEAT LOSS THROUGH WINDOWS BY INFILTRATION

Construction	B. t. u. per hr. per ft. of crack
Poor (1/16" Sash clearance)	2.4
Good (1/32" Sash clearance)	1.2
Weather stripped sash	0.6

By this method the loss due to infiltration will be, for good construction, 1.2 times the specified temperature difference between the outside and inside, usually 70 times the total number of lineal feet of crack. As the leakage of air occurs on the windward side of the building or room and the warm air leaves on the leeward side the total lineal feet of sash and door crack existing in the one outside wall having the maximum glass and door area should be taken only, instead of the total in the room.

The following tests will be of interest in this connection.

WINDOW LEAKAGE

BY STEPHEN F. VOORHEES AND HENRY C. MEYER, JR.

(For the complete paper see A. S. H. V. E., Transactions, Vol. 22, p. 183, 1916.)

The authors conducted a series of experiments to determine the relative infiltration through various types and makes of window sash with and without weather strips. The original paper includes a complete description of the apparatus used and the method of carrying out the tests.

As pointed out by the authors, the tests cover the leakage with certain differences of pressure between the inside and outside of the window which does not simulate exactly the conditions which exist in buildings, as a pressure is built up within the building which retards the flow of air. However, the results which are here shown as curves, give a reliable comparison of the different types of sash and the approximate leakage which might be expected under various wind velocities.

Fig. 1 shows the total leakage for the various windows tested, while Fig. 2 gives the leakage through the perimeter of the sash only.

(See pages 111 and 112)

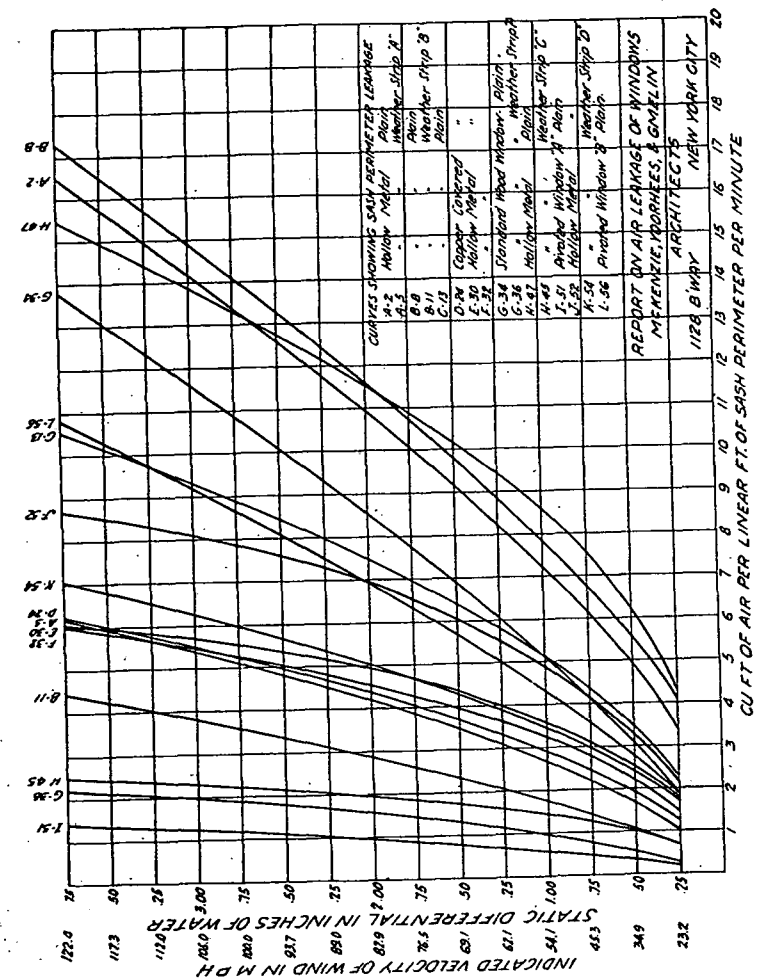


FIG. 1

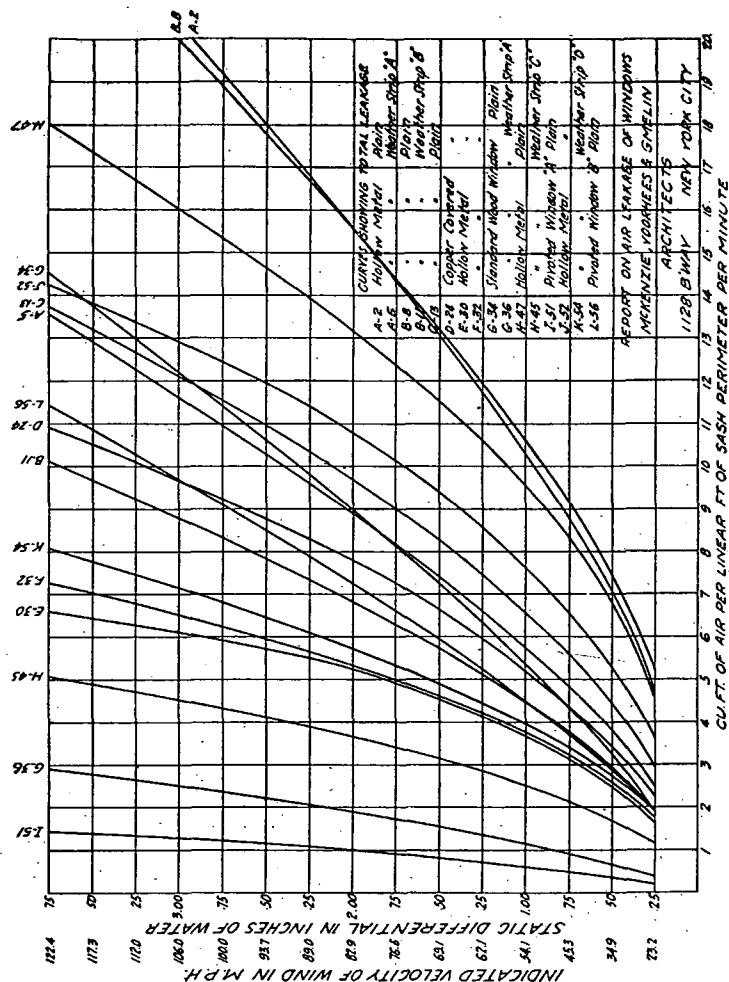


Fig. 2

TRANSMISSION CONSTANTS FOR BUILDING MATERIALS

Buffalo Forge Co. *Fan Engineering*

BRICK WALLS

Thickness Inches	Plain	Plastered One Side	Air Space and Plastered	Furred and Plastered
4	0.52	0.50		0.28
8½	0.37	0.36	0.25	0.23
13	0.29	0.28	0.21	0.20
17½	0.25	0.24	0.19	0.18
22	0.22	0.21	0.16	0.16
26½	0.19	0.18	0.14	

FOR CONCRETE WALLS ADD 20 PER CENT. TO ABOVE VALUES

OUTSIDE WALLS OF FRAME BUILDING-LATH AND PLASTER INSIDE.

Outside Construction	Inside Ordinary Stud Partition
1. Outside Wall	1. Inside Wall
2. Outside Wall	2. Inside Wall
3. Outside Wall	3. Inside Wall
4. Outside Wall	4. Inside Wall
5. Outside Wall	5. Inside Wall
6. Outside Wall	6. Inside Wall
7. Outside Wall	7. Inside Wall
8. Outside Wall	8. Inside Wall
9. Outside Wall	9. Inside Wall
10. Outside Wall	10. Inside Wall
11. Outside Wall	11. Inside Wall
12. Outside Wall	12. Inside Wall
13. Outside Wall	13. Inside Wall
14. Outside Wall	14. Inside Wall
15. Outside Wall	15. Inside Wall
16. Outside Wall	16. Inside Wall
17. Outside Wall	17. Inside Wall
18. Outside Wall	18. Inside Wall
19. Outside Wall	19. Inside Wall
20. Outside Wall	20. Inside Wall
21. Outside Wall	21. Inside Wall
22. Outside Wall	22. Inside Wall
23. Outside Wall	23. Inside Wall
24. Outside Wall	24. Inside Wall
25. Outside Wall	25. Inside Wall
26. Outside Wall	26. Inside Wall
27. Outside Wall	27. Inside Wall
28. Outside Wall	28. Inside Wall
29. Outside Wall	29. Inside Wall
30. Outside Wall	30. Inside Wall
31. Outside Wall	31. Inside Wall
32. Outside Wall	32. Inside Wall
33. Outside Wall	33. Inside Wall
34. Outside Wall	34. Inside Wall
35. Outside Wall	35. Inside Wall
36. Outside Wall	36. Inside Wall
37. Outside Wall	37. Inside Wall
38. Outside Wall	38. Inside Wall
39. Outside Wall	39. Inside Wall
40. Outside Wall	40. Inside Wall
41. Outside Wall	41. Inside Wall
42. Outside Wall	42. Inside Wall
43. Outside Wall	43. Inside Wall
44. Outside Wall	44. Inside Wall
45. Outside Wall	45. Inside Wall
46. Outside Wall	46. Inside Wall
47. Outside Wall	47. Inside Wall
48. Outside Wall	48. Inside Wall
49. Outside Wall	49. Inside Wall
50. Outside Wall	50. Inside Wall
51. Outside Wall	51. Inside Wall
52. Outside Wall	52. Inside Wall
53. Outside Wall	53. Inside Wall
54. Outside Wall	54. Inside Wall
55. Outside Wall	55. Inside Wall
56. Outside Wall	56. Inside Wall
57. Outside Wall	57. Inside Wall
58. Outside Wall	58. Inside Wall
59. Outside Wall	59. Inside Wall
60. Outside Wall	60. Inside Wall
61. Outside Wall	61. Inside Wall
62. Outside Wall	62. Inside Wall
63. Outside Wall	63. Inside Wall
64. Outside Wall	64. Inside Wall
65. Outside Wall	65. Inside Wall
66. Outside Wall	66. Inside Wall
67. Outside Wall	67. Inside Wall
68. Outside Wall	68. Inside Wall
69. Outside Wall	69. Inside Wall
70. Outside Wall	70. Inside Wall
71. Outside Wall	71. Inside Wall
72. Outside Wall	72. Inside Wall
73. Outside Wall	73. Inside Wall
74. Outside Wall	74. Inside Wall
75. Outside Wall	75. Inside Wall
76. Outside Wall	76. Inside Wall
77. Outside Wall	77. Inside Wall
78. Outside Wall	78. Inside Wall
79. Outside Wall	79. Inside Wall
80. Outside Wall	80. Inside Wall
81. Outside Wall	81. Inside Wall
82. Outside Wall	82. Inside Wall
83. Outside Wall	83. Inside Wall
84. Outside Wall	84. Inside Wall
85. Outside Wall	85. Inside Wall
86. Outside Wall	86. Inside Wall
87. Outside Wall	87. Inside Wall
88. Outside Wall	88. Inside Wall
89. Outside Wall	89. Inside Wall
90. Outside Wall	90. Inside Wall
91. Outside Wall	91. Inside Wall
92. Outside Wall	92. Inside Wall
93. Outside Wall	93. Inside Wall
94. Outside Wall	94. Inside Wall
95. Outside Wall	95. Inside Wall
96. Outside Wall	96. Inside Wall
97. Outside Wall	97. Inside Wall
98. Outside Wall	98. Inside Wall
99. Outside Wall	99. Inside Wall
100. Outside Wall	100. Inside Wall

Clapboards 7/16" thick.....	0.44	Lath and plaster, one side.....	0.60
Same with paper lining.....	0.31	Lath and plaster, both sides....	0.34
Same with 3/4" sheathing.....	0.28	Sheet Iron siding.....	1.20
Same with paper and 3/4" sheath- ing.....	0.23	Corrugated Iron siding.....	1.50

FOR VARIOUS WALL CONSTRUCTIONS

Thickness of Board Inches	Pine Board	Double Board Paper Between	Board and Corrugated Iron	Board and Sheet-Iron
½	0.77	0.32	0.45	0.50
1	0.51	0.24	0.36	0.40
1½	0.43	0.19	0.30	0.33
2	0.35	0.16	0.26	0.28
2½	0.30	0.14	0.23	0.25

DOUBLE 1" BOARDS WITH SAWDUST BETWEEN

Sawdust Inches	B. t. u.
2	0.127
4	0.083
6	0.062
8	0.049

FOR FLOOR SURFACES

Single wooden floor, no plaster beneath joists.....	0.45
Same, lath and plaster beneath joists.....	0.26
Double wooden floor, no plaster beneath joists.....	0.31
Same, lath and plaster beneath joists.....	0.18
Concrete—see concrete walls	

Assume temperature of unheated floor space beneath the floor at one-half the difference in temperature between indoors and outdoors.

FLOORS LAID ON THE GROUND

Cement or tile, no wood above.....	0.31
Cement or tile, wood floors above.....	0.10
Dirt, no floor whatever.....	0.20
Wood, single, laid near ground.....	0.10

Assume temperature of earth as plus 30° to 50° F.

FOR GLASS SURFACE AND DOORS

Single windows	1.09
Double windows	0.46
Single skylight	1.16
Double skylight	0.48
Pine Doors, 1"	0.41
" " 1½"	0.32
" " 2"	0.27

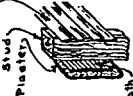
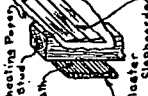
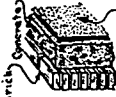
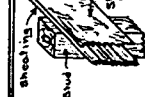
FOR ROOFING PURPOSES

Sheet iron	1.20
Corrugated iron	1.50
Slate on wooden framing	0.85
Slate on 1" boards	0.43
2" boards, paper, tar and gravel	0.26
Patent tar, gravel and paper	0.30
Tiling 1" thick or less	0.80
6" hollow tile covered with 2" concrete, tar and gravel	0.35
2" concrete with cinder fill	0.80
4" " " "	0.60
6" " " "	0.54

L. A. Harding submitted to the Society, in 1913, a paper entitled: Heat Losses by Transmission Through Various Building Materials (see Vol. 19 of the Transactions), from which the following table is reproduced. The data was calculated by the author and checked by experiments which reproduced the conditions existing in buildings.

Tests by John R. Allen (see Vol. 22, Transactions, p. 507) on the transmission through glass under weather conditions suggest a constant of 1.2 for single windows.

Construction	Thickness Inches	B.t.u. Transmitted per Square Ft. per Hour					
		Air Temperature Difference					
		1°	20°	40°	60°	70°	80°
 K = 1.84 C = 0. Plain Brick Wall	9"	.390	7.8	15.6	23.4	27.3	31.2
	13"	.310	6.2	12.4	18.6	21.7	24.8
	18"	.344	4.9	9.8	14.7	17.1	19.6
	24"	.311	4.2	8.4	12.6	14.8	16.8
 K = 1.84 C = 8 for brick C = 10 for mortar Furrowed and Plastered Brick Wall	9"	.303	5.4	10.8	16.2	18.7	21.6
	13"	.219	4.4	8.8	13.2	15.3	17.6
	18"	.191	3.8	7.6	11.4	13.4	15.2
	24"	.160	3.2	6.4	9.6	11.2	12.8
 Wood Wall or Floor		.23	4.6	9.2	13.8	16.1	18.4
			K = .34 for all surfaces C = 1.1 for wood C = 10 for mortar				
 Hollow Tile	6"	.40	8.0	16.0	24.0	28.0	32.0
	12"	.33	7.0	14.0	21.0	24.5	28.0
 Concrete	2"	.70	15.2	30.4	45.6	53.2	60.8
	3"	.53	12.6	25.2	37.8	44.1	50.4
	4"	.58	11.6	23.2	34.8	40.6	46.4
	6"	.51	10.2	20.4	30.6	35.7	40.8
 Windows			K = R + A = .536 + 1.67 = 2.005				
	Single Sash	1.03	20.6	41.2	61.8	72.1	82.4
	Double Sash	.52	10.4	20.8	31.2	36.4	41.6
	Triple Sash	.35	7.0	14.0	21.0	24.5	28.0

HEAT • TRANSMISSION • TABLES • FOR • WALLS •												
Material		A	B	Material	A	B	Material	A	B			
 wall laid Brick Plaster	4"	.60	 Stone Plaster	8"	.98	 Plaster 1/4"	44	 Clapboard Stud	.52	 Sheet Iron	1.20	
	6"	.48		12"	.42							
	12"	.32		16"	.30							
	16"	.24		20"	.23							
	20"	.23		24"	.20							
 Brick Plaster	4"	.60	 Concrete Plaster	8"	.92	 Sheathing Stud Plaster 1/4"	.44	 Sheathing Stud	.44	 Sheet Iron	1.40	
	6"	.36		12"	.30							
	12"	.24		16"	.20							
	16"	.20		20"	.21							
	20"	.21		24"	.18							
 Brick Air-Space Plaster	12"	.22	 Brick Concrete Plaster	12"	.45	 Sheathing Stud Plaster 1/4"	.29	 Paper Board Stud Clapboard	.46	 Sheet Iron	1.00	
	16"	.19		16"	.41							
	20"	.16		20"	.37							
	24"	.14		24"	.33							
	28"	.10		28"	.29							
 Brick Turning 1/4" Plaster	4"	.68	 Brick Hollow Tile Plaster	32"	.25	 Wire Lath Stud Plaster 1/4"	.23	 Paper Board Stud Corrugated Iron	.87	 Plaster	.86	
	6"	.40		10"	.31							
	8"	.30		20"	.27							
	12"	.25		24"	.24							
	16"	.20		30"	.21							
	20"	.18		36"	.18		42"	.16				
	24"	.14		48"	.12							
	28"	.11										
	32"	.08										
	36"	.06										

A: Thickness of Material - B: B.T.U. Loss per Sq. ft. per Degree Difference.

A TEST OF THE CONDUCTIVITY OF WINDOW SHADES

BY JOHN R. ALLEN

The tests reported by the author were conducted to determine the relative amounts of heat transmission through a single strength glass window, close fitting with stops on both sides; *first*, without window shades; *second*, with the inner curtain only pulled down; *third*, with curtains on both sides pulled down and *fourth* with the outer curtain only pulled down. The author summarizes his results as follows:

RESULTS

The results from these tests show that the saving in heat transmitted by the use of the single inside curtain was 19.2 per cent.; by the outside curtain, 28.7 per cent. and by both curtains 42.7 per cent. The marked difference in heat transmission between the tests of the inner curtain and the outer curtain, was without doubt due to the fact that the inner curtain did not fit its opening tightly. This allowed currents of warm air to enter at the top and being cooled between the curtain and the window, to fall and go out through the clearances at the sides and bottom. The outer curtain fitted over the smooth sides of the box about 1½ inches and permitted very little movement of air between it and the window.

The author desires to here render acknowledgment to Prof. Frederick Bass for his assistance in conducting these tests.

RESULTS OF WINDOW SHADE HEAT TRANSMISSION TESTS

Test No	Time Elapsed during Accumulation of 1000 cc. of Melted Water, Minutes	Difference of Temperature Between Inside and Outside Air, deg. Fahr.	Values of Heat Transmission Factor "K" First Column	Corrected Percentages of Heat Saving Over Test No. 1, as Calculated from Uncovered Glass
1—Both shades up.....	35.55	21.6	1.01	.....
2—Inner shade down.....	36.58	26.0	0.817	19.2
3—Both shades down.....	45.93	29.3	0.578	42.7
4—Outer shade down.....	40.38	28.5	0.720	28.7

CALCULATIONS

In order to calculate the transmission heat loss from a room or building multiply the number of square feet of each kind of surface by its constant and then by the difference in temperature between the air in the room or building and the outside air and add together to obtain the total.

EXPOSURE

A certain allowance must be made for the effect of wind on the exposed sides of buildings. The prevailing wind in the coldest weather varies in different localities, and therefore it is impractical to set a definite rule for all places. Where the prevailing wind in the coldest weather is North it is usual practice to add 10 per cent. to the heat loss determined for Northern exposures. H. W. Whitten and R. C. March, (see Transactions, Vol. 22, p. 195) from observations made, give the equivalent drop in temperature for each mile of wind velocity as follows:

DROP IN TEMPERATURE FOR EACH MILE WIND VELOCITY

Temp. Deg. Fahr.	Wind Velocity	Deg. of Temp. Drop
50 deg. to 40 deg.	1 mile per hour equals	0.75 deg. drop
40 deg. to 30 deg.	1 mile per hour equals	1.0 deg. drop
30 deg. to 20 deg.	1 mile per hour equals	1.1 deg. drop
20 deg. to 10 deg.	1 mile per hour equals	1.2 deg. drop
10 deg. to 0 deg.	1 mile per hour equals	1.3 deg. drop
0 deg. to -10 deg.	1 mile per hour equals	1.4 deg. drop
-10 deg. to -20 deg.	1 mile per hour equals	1.5 deg. drop

In other words a temperature of 5 deg. above zero with a 30-mile wind would be equivalent to 34 deg. below zero with no wind blowing. It will be found, however, that the coefficients for transmission allow for a wind velocity of from 10 to 15 miles per hour.

EXAMPLES OF USE OF DATA IN DETERMINING HEAT LOSSES

Assume a living room 15 x 15 ft. with a 10 ft. ceiling. The space below the room is heated while an unheated space exists above the ceiling. The room is exposed on the North and West and each of these walls have a single window 3 x 6 ft. The walls are frame construction with 7/16 in. clapboards, paper and ¾ in. sheathing lathed and plastered on the inside. The ceiling is lath and plaster only. It is desired to heat the room to 70 deg. Fahr. in zero weather, one air change assumed, as there are no outside doors. The calculations, on basis of infiltration by air change method, would be as follows:

Cubical Contents	10 x 15 x 15	=	2250 cu. ft.
Window Area	3 x 6 x 2	=	36 sq. ft.
Net Wall Area	(10 x 15 x 2) - 36	=	264 sq. ft.
Ceiling Area	15 x 15	=	225 sq. ft.
Infiltration	2250 x 0.02 x 70	=	3150 B. t. u.
Net exposed wall	264 x 0.23 x 70	=	4180 B. t. u.
Plus 10 per cent. for Northern exposure		=	418 B. t. u.
Windows	36 x 1.2 x 70	=	3024 B. t. u.
Ceiling	225 x 0.6 x 35	=	4725 B. t. u.
			15497 B. t. u.

If the infiltration had been estimated by the lineal feet of window crack, assuming poor construction, the loss would have been

Ft. of crack of one window (3 x 3) + (6 x 2) = 21 ft. Infiltration — 21 x 2.4 x 70 = 3528 B. t. u. while for good construction the loss due to infiltration would have been 24 x 1.2 x 70 = 1714 B. t. u.

STEAM HEATING

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 data 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 the heat loss in the room in the problem above cited, which was estimated at 15,497 B. t. u. per hour, 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 2 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—2 column 38 in. radiator will be required with a rated surface of 85 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 8 following down the first column to 5 lb. gage pressure and then following over horizontally to 60 deg. fahr. room temperature the conversion factor 0.864 will be found. The heat loss $13,300 \times 0.864$ (the equivalent heat loss) = 11,480 B. t. u. In Table 3 for 3 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 3 column 26 in. radiator will be required.

TABLE 1. HEAT EMITTED BY DIRECT RADIATION—SINGLE-COLUMN RADIATORS
Room Temperature at 70 deg. fahr.
Steam Temperature at 215 deg. fahr.

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.	Rated Surface sq. ft.	Total B.t.u. per hr.	Rated Surface sq. ft.	Rated Surface sq. ft.	Total B.t.u. per hr.	Rated Surface sq. ft.	Rated Surface sq. ft.	Total B.t.u. per hr.	Rated Surface sq. ft.	Rated Surface sq. ft.	Total B.t.u. per hr.	Rated Surface sq. ft.
1	3	1125	2.5	952	770	2	1.66	654	1.66	654	1.5	593	1.5	593	1.5
2	6	1849	5.0	1589	1293	4	3.33	1112	3.33	1112	3.0	982	3.0	982	3.0
3	9	2578	7.5	2217	1807	6	5.00	1555	5.00	1555	4.5	1377	4.5	1377	4.5
4	12	3307	10.0	2845	2321	8	6.66	1997	6.66	1997	6.0	1772	6.0	1772	6.0
5	15	4035	12.5	3471	2835	10	8.33	2440	8.33	2440	7.5	2168	7.5	2168	7.5
6	18	4765	15.0	4098	3348	12	10.00	2882	10.00	2882	9.0	2562	9.0	2562	9.0
7	21	5494	17.5	4725	3863	14	11.66	3324	11.66	3324	10.5	2957	10.5	2957	10.5
8	24	6223	20.0	5354	4377	16	13.33	3767	13.33	3767	12.0	3353	12.0	3353	12.0
9	27	6950	22.5	5982	4891	18	15.00	4209	15.00	4209	13.5	3748	13.5	3748	13.5
10	30	7680	25.0	6610	5404	20	16.66	4652	16.66	4652	15.0	4143	15.0	4143	15.0
11	33	8408	27.5	7236	5918	22	18.33	5095	18.33	5095	16.5	4538	16.5	4538	16.5
12	36	9137	30.0	7863	6432	24	20.00	5538	20.00	5538	18.0	4932	18.0	4932	18.0
13	39	9867	32.5	8489	6947	26	21.66	5980	21.66	5980	19.5	5327	19.5	5327	19.5
14	42	10594	35.0	9117	7459	28	23.33	6422	23.33	6422	21.0	5723	21.0	5723	21.0
15	45	11322	37.5	9744	7974	30	25.00	6865	25.00	6865	22.5	6118	22.5	6118	22.5
16	48	12053	40.0	10372	8489	32	26.66	7309	26.66	7309	24.0	6514	24.0	6514	24.0
17	51	12781	42.5	10999	9000	34	28.33	7752	28.33	7752	25.5	6908	25.5	6908	25.5
18	54	13511	45.0	11624	9515	36	30.00	8193	30.00	8193	27.0	7304	27.0	7304	27.0
19	57	14239	47.5	12250	10028	38	31.66	8635	31.66	8635	28.5	7698	28.5	7698	28.5
20	60	14964	50.0	12875	10544	40	33.33	9080	33.33	9080	30.0	8094	30.0	8094	30.0

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
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
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
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
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
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
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
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
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
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
20	100	22478	80	18656	66.66	16080	53.33	13211	46.66	11736	40	10196

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	6	2241	5	1898	4.5	1665	3.75	1372	3	1138	2.25	878
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
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
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
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
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
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
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
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
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
20	120	25776	100	21990	90.0	20088	75.00	16995	60	14040	45.00	10989

TABLE 4. HEAT EMITTED BY DIRECT RADIATION—FOUR-COLUMN RADIATORS
Steam Temperature at 215 deg. Fahr. *Room Temperature at 70 deg. Fahr.*

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.	Rated Surface sq. ft.	Total B.t.u. per hr.	Rated Surface sq. ft.	Rated Surface sq. ft.	Total B.t.u. per hr.	Rated Surface sq. ft.	Rated Surface sq. ft.	Total B.t.u. per hr.	Rated Surface sq. ft.	Rated Surface sq. ft.	Total B.t.u. per hr.	Rated Surface sq. ft.	Rated Surface sq. ft.	Total B.t.u. per hr.	Rated Surface sq. ft.
1	10	3092	8	2567	6.5	2166	5	1730	4	1430	3	1125	3	1125	3	1125	3	1125
2	20	5000	16	4150	13.0	3513	10	2808	8	2320	6	1823	8	2320	6	1823	6	1823
3	30	6909	24	5730	19.5	4859	15	3887	12	3211	9	2522	12	3211	9	2522	9	2522
4	40	8816	32	7315	26.0	6205	20	4964	16	4101	12	3218	16	4101	12	3218	12	3218
5	50	10725	40	8900	32.5	7550	25	6043	20	4992	15	3917	20	4992	15	3917	15	3917
6	60	12636	48	10483	39.0	8896	30	7122	24	5882	18	4615	24	5882	18	4615	18	4615
7	70	14539	56	12069	45.5	10242	35	8198	28	6773	21	5313	28	6773	21	5313	21	5313
8	80	16445	64	13651	52.0	11588	40	9276	32	7664	24	6011	32	7664	24	6011	24	6011
9	90	18360	72	15235	58.5	12934	45	10355	36	8554	27	6710	36	8554	27	6710	27	6710
10	100	20270	80	16816	65.0	14281	50	11435	40	9444	30	7404	40	9444	30	7404	30	7404
11	110	22176	88	18396	71.5	15627	55	12513	44	10336	33	8103	44	10336	33	8103	33	8103
12	120	24084	96	19978	78.0	16973	60	13592	48	11227	36	8802	48	11227	36	8802	36	8802
13	130	25987	104	21570	84.5	18320	65	14671	52	12118	39	9501	52	12118	39	9501	39	9501
14	140	27902	112	23150	91.0	19665	70	15750	56	13009	42	10198	56	13009	42	10198	42	10198
15	150	29805	120	24732	97.5	21011	75	16827	60	13896	45	10895	60	13896	45	10895	45	10895
16	160	31712	128	26330	104.0	22357	80	17904	64	14784	48	11592	64	14784	48	11592	48	11592
17	170	33626	136	27921	110.5	23702	85	18981	68	15675	51	12291	68	15675	51	12291	51	12291
18	180	35537	144	29506	117.0	25049	90	19961	72	16567	54	12987	72	16567	54	12987	54	12987
19	190	37430	152	31084	123.5	26395	95	21140	76	17459	57	13685	76	17459	57	13685	57	13685
20	200	39340	160	32652	130.0	27742	100	22220	80	18352	60	14382	80	18352	60	14382	60	14382

TABLE 5. HEAT EMITTED BY DIRECT RADIATION—HOSPITAL RADIATORS—TWO COLUMNS
Steam Temperature at 215 deg. Fahr. *Room Temperature at 70 deg. Fahr.*

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.	Rated Surface sq. ft.	Total B.t.u. per hr.	Rated Surface sq. ft.	Rated Surface sq. ft.	Total B.t.u. per hr.	Rated Surface sq. ft.	Rated Surface sq. ft.	Total B.t.u. per hr.	Rated Surface sq. ft.	Rated Surface sq. ft.	Total B.t.u. per hr.	Rated Surface sq. ft.	Rated Surface sq. ft.	Total B.t.u. per hr.	Rated Surface sq. ft.
1	5	1966	4	1628	3.33	1391	2.66	1128	2.33	998	2	861	2.33	998	2	861	2	861
2	10	3118	8	2597	6.66	2219	5.33	1813	4.66	1606	4	1391	4.66	1606	4	1391	4	1391
3	15	4271	12	3558	10.00	3051	8.00	2498	7.00	2213	6	1921	7.00	2213	6	1921	6	1921
4	20	5424	16	4520	13.33	3878	10.66	3179	9.33	2821	8	2448	9.33	2821	8	2448	8	2448
5	25	6575	20	5480	16.66	4710	13.33	3864	11.66	3429	10	2979	11.66	3429	10	2979	10	2979
6	30	7725	24	6439	20.00	5538	16.00	4547	14.00	4036	12	3509	14.00	4036	12	3509	12	3509
7	35	8875	28	7400	23.33	6369	18.66	5228	16.33	4644	14	4038	16.33	4644	14	4038	14	4038
8	40	10028	32	8362	26.66	7196	21.33	5913	18.66	5251	16	4568	18.66	5251	16	4568	16	4568
9	45	11183	36	9324	30.00	8025	24.00	6600	21.00	5859	18	5099	21.00	5859	18	5099	18	5099
10	50	12335	40	10284	33.33	8856	26.66	7282	23.33	6468	20	5626	23.33	6468	20	5626	20	5626
11	55	13487	44	11242	36.66	9684	29.33	7966	25.66	7074	22	6156	25.66	7074	22	6156	22	6156
12	60	14640	48	12206	40.00	10512	32.00	8650	28.00	7683	24	6686	28.00	7683	24	6686	24	6686
13	65	15789	52	13166	43.33	11341	34.66	9330	30.33	8290	26	7215	30.33	8290	26	7215	26	7215
14	70	16940	56	14129	46.66	12169	37.33	10016	32.66	8899	28	7744	32.66	8899	28	7744	28	7744
15	75	18090	60	15084	50.00	13000	40.00	10696	35.00	9506	30	8274	35.00	9506	30	8274	30	8274
16	80	19248	64	16045	53.33	13829	42.66	11378	37.33	10114	32	8803	37.33	10114	32	8803	32	8803
17	85	20400	68	17007	56.66	14658	45.33	12062	39.66	10722	34	9333	39.66	10722	34	9333	34	9333
18	90	21551	72	17971	60.00	15486	48.00	12744	42.00	11327	36	9864	42.00	11327	36	9864	36	9864
19	95	22705	76	18932	63.33	16314	50.66	13425	44.33	11935	38	10393	44.33	11935	38	10393	38	10393
20	100	23850	80	19888	66.66	17142	53.33	14111	46.66	12544	40	10920	46.66	12544	40	10920	40	10920

TABLE 6. HEAT EMITTED BY DIRECT RADIATION—WALL RADIATORS
Room Temperature at 70 deg. Fahr.
Steam Temperature at 215 deg. Fahr.

No. of Sections	9B—29 in.		7B—22 in.		5A—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	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

TABLE 7. HEAT EMITTED BY DIRECT RADIATION—WINDOW RADIATORS
Room Temperature at 70 deg. Fahr.
Steam Temperature at 215 deg. Fahr.

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
2	10	2761	7.50	2156	6	1762
3	15	3816	11.25	2979	9	2441
4	20	4872	15.00	3803	12	3119
5	25	5930	18.75	4626	15	3798
6	30	6987	22.50	5450	18	4477
7	35	8043	26.25	6274	21	5156
8	40	9098	30.00	7098	24	5836
9	45	10152	33.75	7921	27	6516
10	50	11210	37.50	8745	30	7194
11	55	12265	41.25	9570	33	7871
12	60	13320	45.00	10395	36	8550
13	65	14378	48.75	11217	39	9227
14	70	15435	52.50	12038	42	9908
15	75	16490	56.25	12864	45	10589
16	80	17544	60.00	13686	60	13986
17	85	18598	63.75	14510	57	13304
18	90	19656	67.50	15336	48	11266
19	95	20710	71.25	16160	54	12625
20	100	21770	75.00	16988	51	11944

TABLE 8. HEAT EMITTED BY DIRECT RADIATION—CONVERSION FACTORS

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

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.

~ STANDARD CAST IRON RADIATION ~

No. of Radiator Sections	SINGLE COLUMN				TWO COLUMN				THREE COLUMN				FOUR COLUMN				WINDOW				No. of Radiator Sections
	39"	32"	24"	20"	39"	32"	26"	20"	39"	32"	26"	22"	39"	32"	26"	22"	39"	32"	26"	24"	
2	5	6	5	4	3	8	6	5	4	10	9	7	6	4	16	13	10	8	6	9	2
3	7	9	7	6	5	12	10	8	7	15	13	11	9	6	24	19	15	12	9	14	3
4	10	12	10	8	6	16	13	10	8	20	18	15	12	9	32	26	20	16	12	19	4
5	12	15	12	10	8	20	16	13	11	25	22	18	15	11	40	32	25	20	15	23	5
6	15	18	15	12	10	24	20	16	14	30	27	22	18	13	48	39	30	24	18	28	6
7	17	21	17	14	11	28	23	18	16	35	31	26	21	15	56	45	35	28	21	33	7
8	20	24	20	16	13	32	26	21	18	40	36	30	24	18	64	52	40	32	24	38	8
9	22	27	22	18	15	36	30	24	21	45	40	33	27	20	72	58	45	36	27	42	9
10	25	30	25	20	16	40	33	26	23	50	45	37	30	22	80	65	50	40	30	47	10
11	27	33	27	22	18	44	36	29	25	55	49	41	33	24	88	71	55	44	33	52	11
12	30	36	30	24	20	48	40	32	28	60	54	45	36	27	96	78	60	48	36	57	12
13	32	39	32	26	21	52	43	34	30	65	58	48	39	29	104	84	65	52	39	61	13
14	35	42	35	28	23	56	46	37	32	70	63	52	42	31	112	91	70	56	42	66	14
15	37	45	37	30	25	60	50	40	35	75	67	56	45	33	120	97	75	60	45	71	15
16	40	48	40	32	26	64	53	42	37	80	72	60	48	36	128	104	80	64	48	76	16
17	42	51	42	34	28	68	56	43	39	85	76	63	51	38	136	110	85	68	51	80	17
18	45	54	45	36	30	72	60	48	42	90	81	67	54	40	144	117	90	72	54	85	18
19	47	57	47	38	31	76	63	50	44	95	85	71	57	42	152	123	95	76	57	90	19
20	50	60	50	40	33	80	66	53	46	100	90	75	60	45	160	130	100	80	60	95	20
21	52	63	52	42	35	84	70	56	49	105	94	78	63	47	168	136	105	84	63		21
22	55	66	55	44	36	88	73	58	51	110	99	82	66	49	176	143	110	88	66		22
23	57	69	57	46	38	92	76	61	53	115	103	86	69	51	184	149	115	92	69		23
24	60	72	60	48	40	96	80	64	56	120	108	90	72	54	192	156	120	96	72		24
25	62	75	62	50	41	100	83	66	58	125	115	93	75	56	200	162	125	100	75		25
26	65	78	65	52	43	104	86	69	60	130	117	97	78	58	208	169	130	104	78		26

HEATING SURFACE — SQUARE FEET.

The late John R. Allen, while Director of the Society's Research Laboratory, submitted a paper as a report (see A. S. H. V. E. Journal, January, 1920), which in addition to the treatise on the heat emitted by various types of radiation, from which the above tables were calculated gives other data from which the following is taken.

EFFECT OF HUMIDITY

Figure No. 5 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.

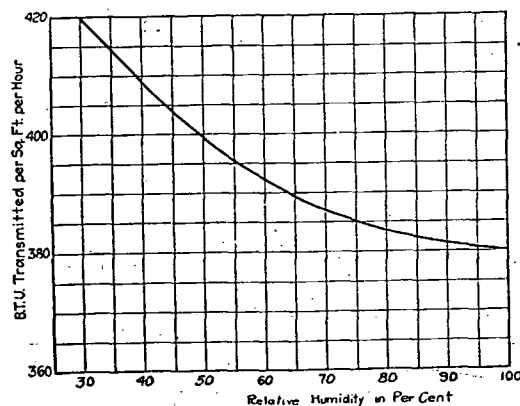


FIG. 5. EFFECT OF HUMIDITY ON HEAT TRANSMISSION

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.

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. The following Table shows the heat loss from a two-column 38 in. radiator, 10 sections long, when painted with different kinds of paints:

EFFECT OF PAINTING ON TWO-COLUMN 38 IN. RADIATOR, STEAM TEMPERATURE 215 DEG. ROOM TEMPERATURE 70 DEG. FAHR.

Condition of Surface	Per Cent.
Cast iron bare	240
Painted with aluminum bronze.....	200
" " gold bronze	205
" " white enamel	242
" " maroon japan	240
" " white zinc paint.....	242
" " no-lustre green enamel.....	230

WARMING THE RADIATOR

It is often very important to know the maximum condensation that occurs in a radiator when steam is turned on. Fig. 6 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 case it amounts to about $3\frac{1}{2}$ 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.

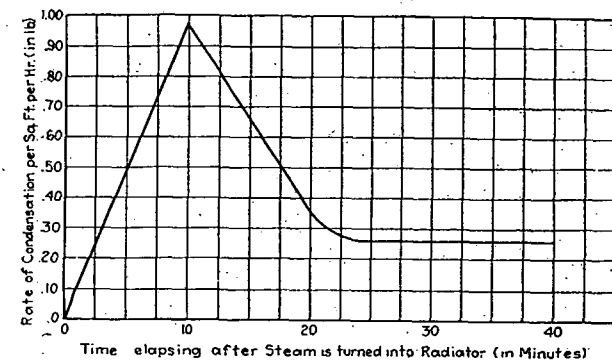


FIG. 6

EFFECT OF ENCLOSING THE RADIATOR

It is very often desirable to partly enclose or conceal a radiator by means of screens or grills. All such enclosures in general reduce the heat transmission from the radiator, the effect being both to reduce the radiant heat and the convected heat. As in most radiators, the convected heat is at least two-thirds of the heat transmission, these enclosures or screens largely affect the convected heat. It is therefore very desirable that the current of air passing over and through the radiator should be restricted as little as possible. There has been some experimental work done, particularly abroad, with reference to these screens. There are, however, so many different cases that may arise that it will not be possible to discuss all of them but only to take up typical ones.

Case No. 1. In this case, Fig. 8, the radiator is enclosed in a box with a screen in front and at the bottom, and a screen at the top, these screens extending the full length of the radiator. This arrangement reduces the heat transmission of the radiator from 7 to 10 per cent. and in all cases, the spaces between the radiator and the wall and the spaces between the casing and the radiator should be at least $2\frac{1}{2}$ inches. The reduction of heat transmission will be more in narrow radiators than in wide radiators. Experiments show that the best results are obtained when the opening at the top has twice the width of the opening at the bottom, and for radiators of ordinary type the width of opening at the bottom should be 5 in. and the opening at the top, 10 in.

Case No. 2. It is sometimes desirable to place a screen in front of the radiator, leaving the top entirely open with an opening at the bottom in front for the cold air to enter the radiator, as in Fig. 9. In a case of this kind the effect of the screen is to produce a strong current of air and if this screen is high enough it may even produce a chimney effect which will increase heat transmission from the radiator due to increased circulation. The effect of such screens depends entirely upon their height. Professor Brabbee states that, with a screen 72 in. high and a 49 in. radiator, the heat transmission will be increased 12 per cent.

Case No. 3. Radiators often have placed over them a flat shelf, as shown in Fig. 10. In such case, they should be provided with a deflector as shown. The effect of the shelf very largely depends upon the height of the shelf above the radiator. When the distance D —that is the height of the shelf above the radiator—is 5 in. or over, the effect of the shelf may be neglected. When the distance D is reduced to 4 in., the heat effect may be reduced by 4 per cent.

Case No. 4. Radiators are often enclosed in boxes with a grill in front or recessed in the wall with a grill placed in front of them as in Fig. 11. In such cases, the height, D , is very important. With D equal to $2\frac{1}{2}$ in., the heat transmission will be reduced 20 per cent., and with D equal to 6 in., the heat transmission is reduced 10 per cent. It is assumed in this case that the entire front of the box is provided with an open grill.

Case No. 5. Sometimes a grill, as shown in Case 4, is partly replaced by a solid panel with openings above and below as in Fig. 12. With the openings the full length of the radiator and 6 in. in height and with D not less than 4 in., the heat transmission will be reduced 25 per cent. As D is reduced in height, the heat transmission will also be reduced and with D , $2\frac{1}{2}$ in., the reduction will be 40 per cent.

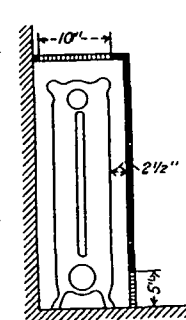


Fig. 8

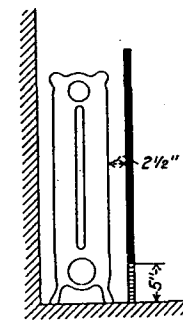


Fig. 9

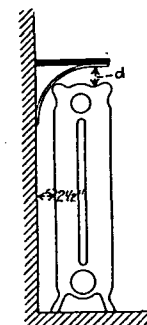


Fig. 10

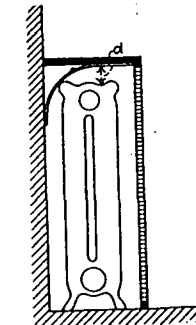


Fig. 11

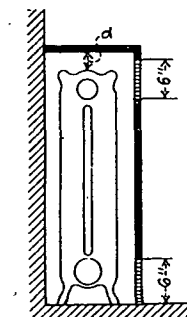


Fig. 12

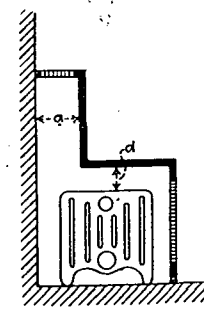


Fig. 13

Case No. 6. Radiators are often placed under seats as in Fig. 13. In this case the distance between the top of the radiator and the bottom of the seat becomes very important and should be not less than 3 in. and if possible it should be made 6 in. Under favorable conditions, when D is at least 3 in. and A is equal to 6 in., the heat transmission will be reduced from 15 to 20 per cent. When D is small, however, say 2 in., and A is reduced to 4 in., this reduction may be 35 or 40 per cent.

In tests¹ by Prof. K. Brabbee will be found other cases than those cited above.

EFFECT OF POSITION

The effect of position on the heat transmission of a radiator is a subject that has been investigated only to a very limited extent. The experiments that are available show that the heat loss from a radiator is about the same whether it is placed at the floor, at the ceiling, or in the center of the room. It seems to make very little difference whether it is placed close to the wall or in the middle of the room. Placing a radiator close to an outside wall heats the wall immediately behind the radiator and if no insulation is placed behind the radiator this may represent a loss of from 3 to 5 per cent.

¹ Reported by George Stumpf, Jr., in *Heating & Ventilating Magazine*, May, 1914, page 23.

HEAT LOSSES FROM BUILDINGS

The following table from *The Establishment of Standard Methods of Proportioning Direct Radiation*, by James A. Donnelly, (Vol. 21, A. S. H. V. E. Transactions, 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:

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 degrees 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.

THE BOILER

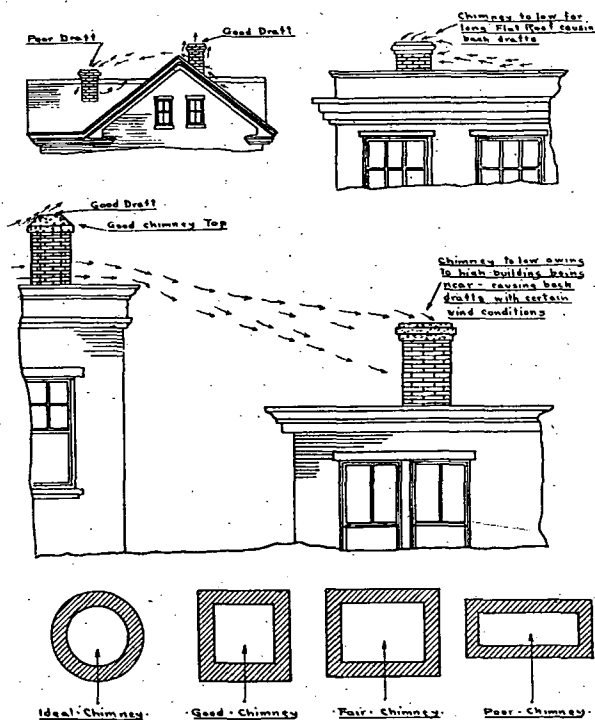
In order to select a boiler to supply sufficient steam for a given amount of radiation there must necessarily be some basis for establishing the steam-producing capacity. To establish such a basis the Society has adopted the Report of the Committee On Code for Testing Low Pressure Heating Boilers (Revision of 1919), which gives a basis for calculating the rating on different firing periods. As will be seen in the Code which is reproduced in full in this volume (page 27) the rating of the boiler in B. t. u. per hour is the product of the number of pounds of dry fuel consumed and the total B. t. u. available at the boiler outlet per pounds of dry fuel, under the test conditions outlined, divided by the duration of firing period in hours.

For house heating installations a firing period of approximately 10 hr. is selected as it permits the fire to be tended only in the morning and evening.

To select the boiler, the total heat emitted by the radiators as calculated above plus that emitted by the piping and connections should be taken as a basis and a boiler selected 50 to 100 per cent. larger than the maker's rating. This factor of safety must be allowed to take care of the decrease in capacity of the boiler under poor draft conditions, soot coated surfaces and inefficient firing, poor quality coal and other conditions which often prevail in the use of such equipment. The ratings given by the manufacturer are under test conditions.

CHIMNEYS

Recommendations for the construction of chimneys and flues have been made in the form of a model ordinance by the *National Board of Fire Underwriters* and approved by the Council of the Society with the exception of the chimney sizes recommended. The ordinance which is reproduced (page 35) shows the sizes that have been recommended by the furnace and boiler manufacturers associations and have been found to give satisfactory service, approval being withheld by the Society only on the ground that they were not as yet considered a recognized standard. The Research Laboratory of the Society is conducting experiments to establish some of the fundamental factors in chimney operation, and the data secured will be published at a later date.



SKETCHES SHOWING SOME CAUSES OF POOR DRAFT IN CHIMNEYS

PIPE SIZES FOR STEAM HEATING

THERE are two broad divisions that may be very definitely made in the subject of steam main sizes. 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 than 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 or average conditions of use should be applied for sizing the pipes within the buildings.

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.

During periods of maximum load on distributing mains, the velocity of flow is often so far above the critical velocity that little, if any, condensation is withdrawn by the drips. At the ends of the runs and especially where the pipe sizes are smaller, the velocities used should be well below the critical velocity so that the condensate is completely withdrawn and not carried into the branch supply mains within the buildings.

There is no formula of flow available for estimating the friction drop of mixtures of steam and condensation or water primed from the boiler. Excessive moisture in the steam, or boiler priming, may so increase the drop in pressure that an entire failure in operation may result. It is, therefore, good practice to provide hand hole or equivalent cleaning means at the bottom of all boilers and a permanent surface blow for boiling off, so that clean water and dry steam may be always maintained. It is quite probable that field research where boilers are priming would show a surprisingly high friction drop in the steam main.

Steam mains should not be dripped on the main trunk lines, and the riser connections and laterals pitched back to the mains. Much better results are obtained by dripping the mains to take care of their condensation, and then pitching the riser connections and laterals to first floor radiators away from the main, and providing additional drips to take care of their condensation separately. In a carefully designed plant, no branch or lateral larger than the supply to a single radiator should be pitched back against the flow of steam, and if it is not certain that the velocity is below the critical limit, the pipe should be provided with a separate drip.

The following tables for the carrying capacities of pipes as used in steam heating installations with the exception of dry returns have been determined by Unwin's formula for the flow of steam in pipes which reads as follows:

$$W = 87.5 \sqrt{\frac{P C d^5}{L (1 + \frac{3.6}{d})}}$$

where W = Weight of steam flowing through the pipe in lb. per minute.
 P = Difference of pressure between the two ends of the pipe.
 C = Density of steam in lb. per cu. ft.
 d = Actual inside diameter of pipe.
 L = Length of pipe in feet.

This formula with the capacity expressed in sq. ft. of radiation on the basis of each sq. ft. of radiation with connected piping condensing 0.3 lb. of steam per hr. will be as follows:

$$R = 17400 \sqrt{\frac{P C d^5}{L (d + 3.6)}}$$

where R = Sq. ft. of radiation.

Capacities of dry returns have been calculated by the Chezy formula for flow in open conduits which is expressed in the form

$$Q = a c \sqrt{r s}$$

where Q = Discharge in cu. ft. per sec.
 a = Wet area of pipe in sq. ft.
 r = Hydraulic mean depth (areas of wet cross-section divided by the wet-perimeter.)
 c = Constant from Kutter's formula.
 s = Slope or grade.

In the tables for one-pipe, two-pipe and vapor systems without the use of thermostatic traps the tables have been calculated on the basis of the water occupying $\frac{1}{8}$ the area of the pipe while for vapor systems using thermostatic traps the capacity is based on water occupying $\frac{3}{16}$ the area.

All supply mains, branches to risers, when dripped, where steam and condensation flow in the same direction, and supply risers, (with the exception of up feed one-pipe risers) are based on a pressure drop of 1 oz. per 100 ft. length of pipe or equivalent.

All supply mains, branches to risers, not dripped where condensation and steam are flowing in opposite directions and up feed one-pipe risers are based on a velocity of 16 ft. per sec.

Branches to radiators 5 ft. in length or less are based on velocities from 10 to 19 ft. per sec. depending on the size of branch while branches to radiators 5 to 10 ft. in length are based on a velocity of approximately 10 ft. per sec.

Wet returns are calculated on a drop of $\frac{1}{2}$ oz. per 100 ft. length of pipe or equivalent.

Radiator valve sizes for one and two pipe gravity systems are based on standard practice.

An allowance must be made for ells and fittings in the line of flow by adding the number of feet given in the table to the straight run of pipe to obtain the total equivalent length.

Table 1.

ONE PIPE STEAM

CAPACITY IN SQ. FT. OF RADIATION

Com- mercial Pipe Sizes	B Supply Main Branch to Radiator Risers and water flowing same direction	C Supply Main Branch to Radiator Risers and water flowing opposite direction	D Branches to Radiators 5 ft. in length or less	E Wet Main length	F Dry Drip Grade in 10 ft. in 1 inch or 1 inch in 5 ft.	G Radiator Valve Sizes	H Allowance in ft. of pipe for Ells and Fittings
$\frac{1}{4}$	40	40	24	800	180	24	0.8
$1\frac{1}{4}$	75	75	60	1,800	420	24	1.3
$1\frac{1}{2}$	150	150	100	3,000	900	24	1.9
2	300	170	200	6,000	1,500	60	2.1
$2\frac{1}{2}$	500	220	300	10,000	2,100	100	3.2
3	800	340	400	18,000	3,500	200	4.2
$3\frac{1}{2}$	1,500	460	600	25,000	4,900	200	6.5
4	2,000	600	800	37,000	9,800	200	12
$4\frac{1}{2}$	2,800	800	1,000	57,000	14,000	200	15
5	3,600	1,000	1,200	75,000	18,000	200	19
6	4,800	1,200	1,400	100,000	22,000	200	22
7	6,000	1,400	1,600	125,000	26,000	200	26
8	9,000	1,600	1,800	150,000	30,000	200	34
10	13,000	1,800	2,000	175,000	34,000	200	41
12	21,000	2,000	2,200	200,000	38,000	200	48
							68
							86

Length Factors—For supply mains where steam and water are flowing in the same direction and for wet returns where lengths are other than 100 ft. multiply the factor here given by the sq. ft. of radiation to determine the carrying capacity of the pipe.

Length in Feet 200 300 400 500 1000
 Factor..... 0.710 0.576 0.500 0.447 0.316
 To obtain size of supply mains (not dripped) and down feed risers where steam and water are flowing in the same direction, add amount of radiation the pipe is to supply steam to, and $\frac{1}{4}$ the radiation the pipe is carrying water from, and size as for steam mains (Column B). Where main is dripped at each point of reduction or offener use Column E.

The end of steam mains, if reduced, to be one size larger than table calls for. On circuit mains where reduced and not dripped use eccentric coupling for making reduction.
 In installations in buildings 3 stories or more in height each up-feed riser should be separately dripped into wet drip main. In tall buildings where risers are 100 ft. in length, or over, horizontal run-outs, to permit expansion or, where necessary, due to the design of building, should have separate drips carried down to basement into drip return line.

Table 2.

TWO-PIPE STEAM

CAPACITY OF PIPES IN SQ. FT. OF RADIATION

A Com- mercial Pipe Size	B Supply Main Branch to Risers Up-Feed Risers Steam and water flowing same direction	C Branches to Risers Steam and water flowing opposite direction	D Branches to Radiators 5 ft. in length or less	E Wet Return Main in 5 ft. length	F DRY RETURN MAIN Grade in Inches 1 inch 10 ft. 1 inch 20 ft. 1 inch 30 ft.	G Radiator Valves Supply Return 30 ft.	H Allowance in ft. of pipe for Globe Valves Ells
3/4	40	49	24	1800	180	100	40
1	75	75	60	1800	420	210	80
1 1/4	150	100	100	1800	630	320	170
1 1/2	300	170	160	2000	1050	550	320
2	500	220	200	3000	1500	800	480
2 1/2	750	340	300	4000	2100	1200	640
3	1000	460	400	5000	2800	1600	800
3 1/2	1500	600	500	6000	3500	2000	960
4	2000	800	600	7000	4200	2400	1120
4 1/2	2800	1000	700	8000	5000	2800	1280
5	3600	1200	800	9000	5800	3200	1440
6	6000	1500	1000	10000	6600	3600	1600
7	9000	1800	1200	11000	7400	4000	1760
8	13000	2200	1400	12000	8200	4400	1920
10	23000	3000	2000	14000	9800	5200	2240
12	37000	4000	2800	18000	12000	6000	2560

NOTES

Length Factor. For supply mains where steam and water are flowing in the same direction and for wet returns where lengths are other than 100 ft. multiply the factor here given by the sq. ft. of radiation to obtain the carrying capacity of the pipe.

Length in Feet 200 300 400 500 1000 2000 3000
Factors 0.710 0.576 0.500 0.447 0.316 0.223 0.182

Supply mains to be sized according to Column B.
Where branches to risers are taken from top of main the main should be dripped at the end either by a separate drip line or into the main return line. The end of the main, if reduced, to be one size larger than table calls for. Where branches to risers are taken from bottom of main the main should be dripped at the bottom of the main, if reduced, to be one size larger than table calls for. If this is not done eccentric couplings should be used for making reduction. The bottom of down-feed supply risers should be carried down to the basement level and connected to separate drip mains or into the main return.

In buildings where risers are 100 ft. in length or over, horizontal run-outs, to take care of expansion, or where necessary, due to design of building, should have separate drips, carried down to basement into separate drip main or into the main return.

Table 3.

LOW PRESSURE GRAVITY VAPOR

WITH USE OF THERMOSTATIC TRAPS

CAPACITY OF PIPES IN SQ. FT. OF RADIATION

A Com- mercial Pipe Size	B Supply Main Branch to Risers Up-Feed Risers (dripped) Steam and water flowing same direction	C Branches to Radiators Steam and water flowing opposite direction	D Branches to Radiators 5 ft. in length or less	E Wet Return Main in 5 ft. length	F DRY RETURN MAINS Grade in Inches 1 inch 10 ft. 1 inch 20 ft. 1 inch 30 ft.	G Allowance in ft. of pipe for Globe Valves Ells
3/4	40	49	24	1800	180	100
1	75	75	60	1800	420	210
1 1/4	150	100	100	2000	630	320
1 1/2	300	170	160	3000	1050	550
2	500	220	200	4000	1500	800
2 1/2	750	340	300	5000	2100	1200
3	1000	460	400	6000	2800	1600
3 1/2	1500	600	500	7000	3500	2000
4	2000	800	600	8000	4200	2400
4 1/2	2800	1000	700	9000	5000	2800
5	3600	1200	800	10000	5800	3200
6	6000	1500	1000	11000	6600	3600
7	9000	1800	1200	12000	7400	4000
8	13000	2200	1400	13000	8200	4400
10	23000	3000	2000	14000	9800	5200
12	37000	4000	2800	18000	12000	6000

NOTES

Length Factor. For supply mains where steam and water are flowing in the same direction and for wet returns where lengths are other than 100 ft. multiply the factor here given by the sq. ft. of radiation to obtain the carrying capacity of the pipe.

Length in Feet 200 300 400 500 1000 2000 3000
Factors 0.710 0.576 0.500 0.447 0.316 0.223 0.182

Supply mains to be sized according to Column B.
Where branches to risers are taken from the top of the main, the main should be dripped at the end either by a separate drip line or into the main dry return line through a trap. The end of steam mains, if reduced, to be one size larger than the table calls for.

Where the main changes size branch connections should be taken from the bottom of the main and either connected into separate drip main or into main dry return line through a trap. If this is not done eccentric couplings should be used for making reductions.

The bottom of risers should be carried down to the basement and connected to separate drip main or into dry return main through a trap.
In buildings where risers are 100 ft. in length or over, horizontal run-outs, to take care of expansion, or where necessary, due to the design of the building, should have separate drips, carried down to basement into separate drip main or into the dry return through a trap.

Table 4.

LOW PRESSURE GRAVITY VAPOR

WITHOUT USE OF THERMOSTATIC TRAPS

CAPACITY IN PIPES IN SQ. FT. OF RADIATION

A Com- mercial Pipe Sizes	B Supply Main Up-feed Risers Branches to Risers (dripped) Steam and water flowing same direction	C Branches to Risers Steam and water flowing opposite direction	D Branches Radiators 5 ft. in length or less	E Wet Return Main 10 ft. in length	F DRY RETURN MAINS Grade in Inches			G Allowance in ft. of pipe for Globe Valves
					Vertical in 5 ft. or 1 inch	1 inch in 10 ft.	1 inch in 20 ft.	
¾	40	40	24	...	180	140	100	0.8
1	75	75	60	...	420	300	210	1.2
1½	150	150	100	...	900	650	450	1.9
2	300	300	200	...	1800	1300	900	3.2
2½	450	450	300	...	2700	2000	1350	4.2
3	600	600	400	...	3600	2700	1800	5.5
3½	750	750	500	...	4500	3300	2250	6.5
4	900	900	600	...	5400	3900	2600	9.
4½	1050	1050	700	...	6300	4500	3000	12.
5	1200	1200	800	...	7200	5100	3400	15.
6	1350	1350	900	...	8100	5700	3800	19.
7	1500	1500	1000	...	9000	6300	4200	22.
8	1650	1650	1100	...	9900	6900	4600	26.
9	1800	1800	1200	...	10800	7500	5000	31.
10	1950	1950	1300	...	11700	8100	5400	34.
12	2300	2300	1500	...	13800	9600	6400	41.
14	2650	2650	1700	...	15900	10900	7300	48.
16	3000	3000	1900	...	18000	12200	8100	57.

NOTES

Length Factor. For supply mains where steam and water are flowing in the same direction and for wet returns where lengths are other than 100 ft. multiply the factor here given by the sq. ft. of radiation to obtain the carrying capacity of the pipe.

Length in Feet 200 300 400 500 1000 2000 3000

Factors 0.710 0.576 0.500 0.447 0.316 0.223 0.182

Supply mains to be sized according to Column B.

Where branches to risers are taken from the top of the main, the main should be dripped at the end either by a separate drip line or into the main dry return line through a trap. The end of steam mains, if reduced, to be one size larger than the table calls for.

Where the main changes size, branch connections should be taken from the bottom of the main and either connected into separate drip main or into main dry return line through a trap. If this is not done eccentric couplings should be used for making reductions.

The bottom of risers should be carried down to the basement level and connected to separate drip main or into dry return main through a trap.

In buildings where risers are 100 ft. in length or over, horizontal run-outs, to take care of expansion, or where necessary, due to the design of the building, should have separate drips, carried down to basement into separate drip main or into the dry return through a trap.

TABLE 5.
CAPACITIES OF STEAM AND RETURN MAINS FOR VACUUM
SYSTEMS—CAPACITIES IN RADIATION, SQUARE FEET.

A Pipe Size, Inches	B Steam Rating	C Main Return	D BRANCH RETURNS		
			Return Risers	Radiator Connections	Drips Inches
½	.....	.....	.....	100	...
¾	20	600	400	200	...
1	40	1,200	600	400	...
1¼	75	2,400	1,200	600	...
1½	150	4,800	2,400	...	¾
2	300	9,000	4,800	...	¾
2½	500	15,000	...	...	¾
3	900	23,000	...	...	1
3½	1,500	37,000	...	...	1
4	2,000	55,000	...	...	1
4½	2,800	78,000	...	...	1½
5	3,600	...	...	...	1½
6	6,000	...	...	...	1½
7	9,000	...	...	...	...
8	13,000	...	...	...	...
9	18,000	...	...	...	...
10	23,000	...	...	...	...
12	37,000	...	...	...	...
14	55,000	...	...	...	...
16	78,000	...	...	...	...

Length Factors.—For supply mains where steam and water are flowing in the same direction and for wet returns where lengths are other than 100 ft., multiply the factor here given by the sq. ft. of radiation to obtain the carrying capacity of the pipe.

Length in Feet.....	200	300	400	500	1000	2000	3000
Factor	0.710	0.576	0.500	0.447	0.316	0.223	0.182

Supply mains to be sized according to Column B.

Where branches to risers are taken from the top of the main, the main should be dripped at the end either by separate drip line or into the main dry return line through a trap. The end of steam mains, if reduced, to be one size larger than the table calls for.

Where the main changes size branch connections should be taken from the bottom of the main and either connected into separate drip main or into main dry return line through a trap. If this is not done eccentric couplings should be used for making reductions.

The bottom of risers should be carried down to the basement level and connected to separate drip main or into dry return main through a trap.

In buildings where risers are 100 ft. in length or over, horizontal run-outs, to take care of expansion, or where necessary due to the design of the building, should have separate drips carried down to basement into separate drip main or into the dry return through a trap.

TABLE 6. CAPACITIES OF STEAM DISTRIBUTING MAINS, WITH A TOTAL FRICTION OF 1 LB. FOR THE LENGTH OF RUN—RADIATION IN SQUARE FEET—UNWIN FORMULA—NOMINAL SIZES OF PIPE

Pipe Size, Inches	LENGTH OF RUN IN FEET							
	300	400	600	800	1,000	1,200	1,500	2,000
4	3,300	2,800	2,300	2,000	1,800	1,600	1,450	1,250
4½	4,600	3,950	3,200	2,800	2,500	2,300	2,050	1,750
5	5,900	5,100	4,100	3,600	3,200	2,950	2,600	2,250
6	9,800	8,500	7,000	6,000	5,500	4,900	4,400	3,800
7	14,700	12,800	10,500	9,000	8,250	7,350	6,600	5,700
8	21,000	18,400	15,000	13,000	11,900	10,600	9,500	8,200
9	29,400	25,600	21,000	18,000	16,500	14,700	13,200	11,400
10	37,600	32,600	27,000	23,000	21,100	18,800	16,900	14,600
12	60,400	52,500	43,000	37,000	34,000	30,200	27,100	23,400
14	89,800	78,000	64,000	55,000	50,400	45,000	40,300	34,800
16	127,400	110,000	91,000	78,000	71,500	63,700	57,200	49,400

Calculated on the assumption that fittings, entrained water, etc., double the friction of straight pipe.

Maximum condensation of radiating surface and connected pipes taken at 0.3 lb. per sq. ft. per hour.

CAPACITIES OF SUPPLY MAINS IN DIRECT C. I. RADIATION

Pipe Size, Inches	LENGTH OF MAIN IN FEET—¼-LB. PRESSURE DROP					
	400	500	750	1,000	1,250	1,500
2½	520	470	370	330	290	260
3	950	890	720	630	560	500
3½	1,430	1,280	1,030	900	810	710
4	2,020	1,810	1,460	1,280	1,140	1,000
4½	2,750	2,460	1,980	1,740	1,560	1,350
5	3,770	3,370	2,700	2,380	2,130	1,880
6	6,150	5,400	4,410	3,890	3,480	3,080
7	8,300	7,420	5,970	5,240	4,680	4,000
8	12,840	11,480	9,210	8,110	7,260	6,400
10	23,440	20,950	17,840	14,810	13,250	11,700

NOTE: Allowance must be made for ells and fittings in the line of flow.

Sizes of Steam Mains for Direct Radiation

SHOWING LOSS OF PRESSURE IN OUNCES FOR 100 FT. RUN. UNWIN FORMULA

Velocity feet per sec.		CONDENSATION THREE-TENTHS LB. PER SQ. FT. PER HOUR.		NOMINAL SIZES OF PIPE USED.		100 ft. Run 1 in. Drop		130 Ft.		120 Ft.		110 Ft.		100 Ft.		90 Ft.		80 Ft.		70 Ft.		60 Ft.		50 Ft.		40 Ft.		30 Ft.		20 Ft.		10 Ft.	
Size of Main		Sq. Ft. Rad'n.	Drop.	Sq. Ft. Rad'n.	Drop.	Sq. Ft. Rad'n.	Drop.	Sq. Ft. Rad'n.	Drop.	Sq. Ft. Rad'n.	Drop.	Sq. Ft. Rad'n.	Drop.	Sq. Ft. Rad'n.	Drop.	Sq. Ft. Rad'n.	Drop.	Sq. Ft. Rad'n.	Drop.	Sq. Ft. Rad'n.	Drop.	Sq. Ft. Rad'n.	Drop.	Sq. Ft. Rad'n.	Drop.	Sq. Ft. Rad'n.	Drop.	Sq. Ft. Rad'n.	Drop.	Sq. Ft. Rad'n.	Drop.	Sq. Ft. Rad'n.	Drop.
1 in.	4	25	1.6	49	2.6	74	4.6	100	7.4	125	11.6	150	16.6	175	21.6	200	26.6	225	31.6	250	36.6	275	41.6	300	46.6	325	51.6	350	56.6	375	61.6	400	66.6
1½ in.	8	3	1.6	98	2.6	147	4.6	196	7.4	245	11.6	294	16.6	343	21.6	392	26.6	441	31.6	490	36.6	539	41.6	588	46.6	637	51.6	686	56.6	735	61.6	784	66.6
2 in.	12	5	1.6	147	2.6	221	4.6	294	7.4	367	11.6	440	16.6	513	21.6	586	26.6	659	31.6	732	36.6	805	41.6	878	46.6	951	51.6	1,024	56.6	1,097	61.6	1,170	66.6
2½ in.	16	7	1.6	196	2.6	294	4.6	392	7.4	490	11.6	588	16.6	686	21.6	784	26.6	882	31.6	980	36.6	1,078	41.6	1,176	46.6	1,274	51.6	1,372	56.6	1,470	61.6	1,568	66.6
3 in.	20	9	1.6	245	2.6	367	4.6	490	7.4	613	11.6	735	16.6	858	21.6	980	26.6	1,103	31.6	1,225	36.6	1,348	41.6	1,470	46.6	1,593	51.6	1,715	56.6	1,838	61.6	1,960	66.6
3½ in.	24	11	1.6	294	2.6	440	4.6	588	7.4	735	11.6	882	16.6	1,029	21.6	1,176	26.6	1,323	31.6	1,470	36.6	1,617	41.6	1,764	46.6	1,911	51.6	2,058	56.6	2,205	61.6	2,352	66.6
4 in.	28	13	1.6	343	2.6	513	4.6	686	7.4	858	11.6	1,029	16.6	1,200	21.6	1,372	26.6	1,543	31.6	1,715	36.6	1,886	41.6	2,058	46.6	2,229	51.6	2,400	56.6	2,571	61.6	2,742	66.6
4½ in.	32	15	1.6	392	2.6	586	4.6	784	7.4	980	11.6	1,176	16.6	1,372	21.6	1,568	26.6	1,764	31.6	1,960	36.6	2,156	41.6	2,352	46.6	2,548	51.6	2,744	56.6	2,940	61.6	3,136	66.6
5 in.	36	17	1.6	440	2.6	659	4.6	882	7.4	1,078	11.6	1,274	16.6	1,470	21.6	1,666	26.6	1,862	31.6	2,058	36.6	2,254	41.6	2,450	46.6	2,646	51.6	2,842	56.6	3,038	61.6	3,234	66.6
6 in.	44	21	1.6	539	2.6	805	4.6	1,078	7.4	1,274	11.6	1,470	16.6	1,666	21.6	1,862	26.6	2,058	31.6	2,254	36.6	2,450	41.6	2,646	46.6	2,842	51.6	3,038	56.6	3,234	61.6	3,430	66.6
8 in.	56	27	1.6	686	2.6	1,029	4.6	1,323	7.4	1,543	11.6	1,817	16.6	2,091	21.6	2,365	26.6	2,639	31.6	2,913	36.6	3,187	41.6	3,461	46.6	3,735	51.6	4,009	56.6	4,283	61.6	4,557	66.6
10 in.	68	33	1.6	838	2.6	1,274	4.6	1,568	7.4	1,817	11.6	2,091	16.6	2,365	21.6	2,639	26.6	2,913	31.6	3,187	36.6	3,461	41.6	3,735	46.6	4,009	51.6	4,283	56.6	4,557	61.6	4,831	66.6
12 in.	80	39	1.6	980	2.6	1,470	4.6	1,764	7.4	2,058	11.6	2,352	16.6	2,646	21.6	2,940	26.6	3,234	31.6	3,528	36.6	3,822	41.6	4,116	46.6	4,410	51.6	4,704	56.6	5,000	61.6	5,294	66.6
14 in.	92	45	1.6	1,176	2.6	1,764	4.6	2,091	7.4	2,365	11.6	2,639	16.6	2,913	21.6	3,187	26.6	3,461	31.6	3,735	36.6	4,009	41.6	4,283	46.6	4,557	51.6	4,831	56.6	5,105	61.6	5,379	66.6
16 in.	104	51	1.6	1,372	2.6	1,960	4.6	2,254	7.4	2,548	11.6	2,842	16.6	3,136	21.6	3,430	26.6	3,724	31.6	4,018	36.6	4,312	41.6	4,606	46.6	4,899	51.6	5,193	56.6	5,487	61.6	5,781	66.6

FLOW OF STEAM IN PIPES

Pressure Drop in Ounces	$87\sqrt{\frac{\text{Drop}}{100}}$	Inside Dia. Pipe Inches	$\sqrt{\frac{D^5}{1 + \frac{3.6}{D}}}$	Steam Pressure	$\sqrt{\text{Density}}$	Length Pipe in Inches	$\sqrt{\frac{100}{\text{Length}}}$
1	2.175	1	.522	0	.193	20	2.240
2	3.076	1 1/4	1.177	.3	.195	40	1.580
3	3.767	1 1/2	1.828	1.3	.201	60	1.290
4	4.350	2	3.709	2.3	.207	80	1.120
5	4.863	2 1/2	6.109	5.3	.223	100	1.000
6	5.328	3	11.183	10.3	.248	120	.912
7	5.754	3 1/2	16.705	15.3	.270	140	.841
8	6.152	4	23.630	20.3	.290	160	.793
10	6.878	4 1/2	32.098	30.3	.326	180	.741
12	7.534	5	43.719	40.3	.358	200	.710
14	8.138	6	69.718	50.3	.388	250	.632
16	8.700	7	105.35	60.3	.415	300	.578
20	9.727	8	150.33	75.3	.452	350	.538
24	10.655	9	205.37	100.3	.507	400	.500
28	11.509	10	271.16	125.3	.557	450	.477
32	12.290	12	437.51	150.3	.603	500	.447
40	13.756	14	733.90	175.3	.645	600	.407
48	15.069	16	925.19	200.3	.648	700	.378
80	19.454					800	.354
160	27.512					900	.333
320	38.863					1000	.316
480	47.652					1400	.267

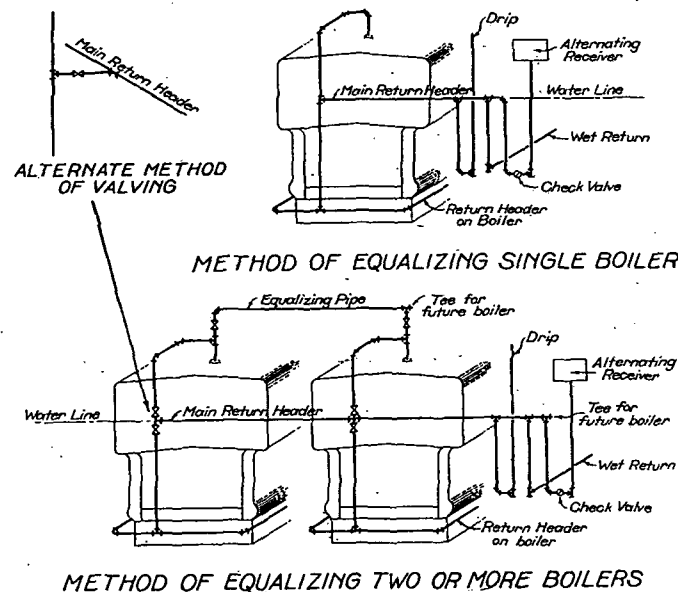
$A \times B \times C \times D$ = lbs. steam per minute will flow through a pipe for a given condition. Example
 $4.35 \times 11.183 \times 223 \times 1.00 = 10.84$ lbs. per minute— $10.84 \times 60 = 650.4$ lbs. per hour.

d = Drop in pressure in lbs.
 d = inside dia. pipe in inches
 L = Length of pipe in feet
 D = Density of steam per cu.ft.
 W = lbs. of steam per minute

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

$$P = .000131 \left(1 + \frac{3.6}{d}\right) \frac{W^2 L}{Dd^5}$$

METHODS OF EQUALIZING BOILERS



WATER HAMMER



Water hammer in steam pipes is caused by condensation in the pipe forming waves and allowing pockets to form holding steam—similar to A. The air around the pipe being cooler than the steam causes the steam to condense, thereby making a vacuum which pulls the water B-B together with a slap or bang. If the pipe is large enough to permit the steam to travel at a low velocity it will not pick up the water and form waves; like the above drawing and water hammer will not occur.

CARE OF STEAM BOILERS

CLEANING STEAM BOILERS

The steam boiler should be cleaned within one week after it is installed and in operation. This should be done to remove any accumulation of oil, grease, etc., which has a tendency to cause the boiler to foam, producing a very unsteady water line. It is thus necessary to blow off the boiler under pressure. If one blowing-off does not result in a steady water line and clear gauge-glass, the operation must be repeated a second and if necessary a third or fourth time.

Close all radiator valves, or, if the mains are equipped with valves, close both flow and return valves tightly.

Fill the boiler to the top of the gauge with water. Build a hot fire in the boiler and get up a pressure of 10 to 15 lb.

Open the blow-off cock and be careful that sufficient fire is carried to maintain a pressure until the boiler is empty.

After doing this, draw the remaining fire and allow the boiler to cool down thoroughly. This will require one-half to one hour's time, after which close the blow-off cock and slowly fill boiler to water line.

Open all radiator valves or valves on flow and return mains and rebuild fire, and the heating plant is ready for operation.

HOW TO CLEAN A WATER-GAUGE GLASS ON A STEAM BOILER WITHOUT REMOVING IT

1. Draw a cupful of hot water from the boiler, into which pour at least a table-spoon of raw muriatic or other acid.
2. Close both water-gauge valves.
3. Open top water-gauge valve and also pet cock at bottom, and blow water out of glass. Then immediately close the top valve and submerge the end of the pet cock in cup of hot-water solution. A vacuum is at once created in the gauge glass which causes the solution in the cup to rush in.
4. Keep the pet cock immersed and operate the top valve, slightly opening and closing, alternately expelling and drawing in the solution until all grease, oil, or other matter adhering to the inside of the glass is cut out. Then close pet cock and open both water-gauge valves.

It is necessary to have 1 lb. pressure of steam or more on the boiler before commencing this operation, which need not occupy more than 10 minutes. The result is a clean glass without the risk of breakage and probable renewal of gaskets, which is frequently the case when removing the glass for cleaning.

PIPE SIZES FOR GRAVITY HOT WATER HEATING

(From Mechanical Equipment of Federal Buildings, By Nelson S. Thompson)

TWO-PIPE HOT-WATER BASEMENT MAINS, GRAVITY CIRCULATION, DIRECT RADIATOR TAPPINGS

First Floor	Second Floor	Third Floor	Fourth Floor	Pipe Size Inches
40	50	60	70	¾
70	80	90	100	1
110	120	135	150	1¼
180	195	210	230	1½
300	350	400	500	2

At ends of mains increase tapping one size. No main to be less than 1¼ in.

To get size of mains and risers serving more than one radiator, add area of tappings together and use the following:

EQUALIZING TABLE

Inches		Inches	
½ equals	2	3 equals	175
¾ equals	5	3½ equals	260
1 equals	10	4 equals	380
1¼ equals	20	5 equals	650
1½ equals	30	6 equals	1,050
2 equals	60	7 equals	1,600
2½ equals	110	8 equals	2,250

To get size pipe to serve a ¾-inch pipe and a 1-inch pipe:

¾ in. equals 5
1 in. equals 10

15 equals 1¼ in.

Expansion tanks are made 1 gal. to 30 sq. ft. radiation up to 1,000 sq. ft.; 1 gal. to 40 sq. ft. 1,000 to 2,000 sq. ft.; 1 gal. to 50 sq. ft. 2,000 to 5,000 sq. ft., and 1 gal. to 60 sq. ft. for jobs above 5,000 sq. ft. in radiators.

THE FRICTION OF WATER IN IRON PIPES AND ELBOWS

By F. E. GIESECKE

Data and experiments carried out by the Division of Engineering, Bureau of Economic Geology and Technology of the University of Texas, led to the establishment of the formula

$$h = 0.00685 \frac{v^{1.77}}{d^{1.275}}$$

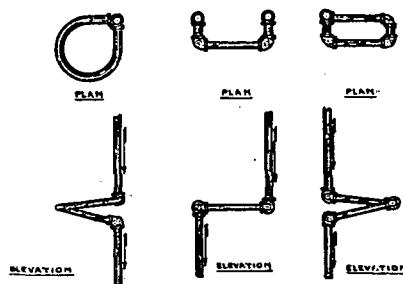
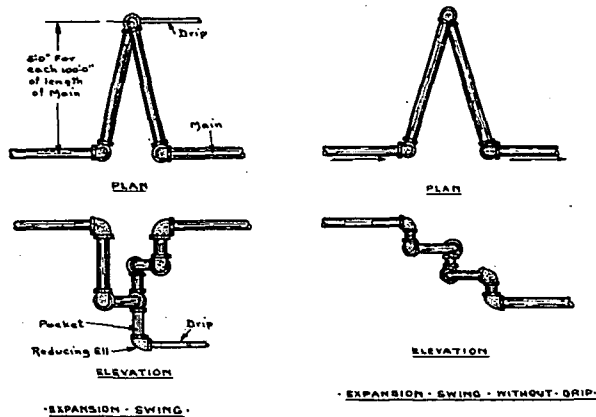
showing the relation between the friction of flow of water (h) and the velocity (v) for clean iron pipes ranging in size from ½ to 3 in. when the water has a temperature of about 68 deg. fahr. and flows at velocities up to 3 ft. per sec.

The friction of water at temperature of about 68 deg. fahr. in one standard short-radius steam elbow is given by

$$h = 0.0141 \frac{v^{1.96}}{d^{0.26}}$$

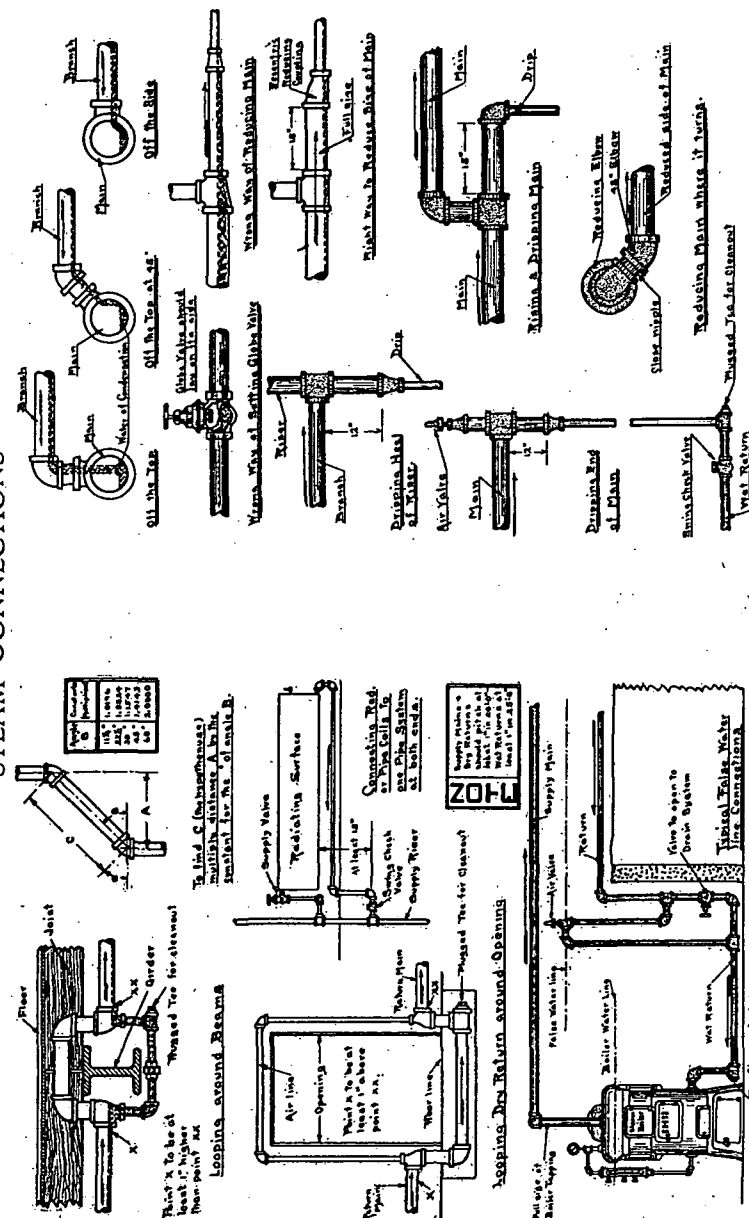
(For the complete paper see Transactions A. S. H. V. E., Vol. XXIII, 1917, p. 499.)

EXPANSION CONNECTIONS

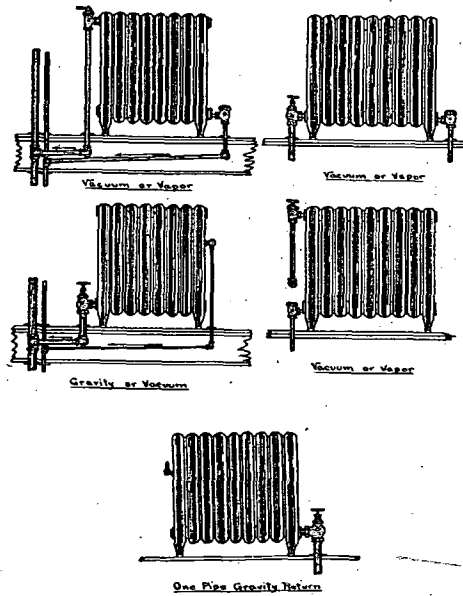


NOTE—Allowance for expansion must be made in long runs of mains both vertical and horizontal. One expansion joint or swing should be installed in any run over 100'-0" long and one for each additional 100'-0" of run. All branch connections should be made so as to allow a swing both at the main and the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

STEAM CONNECTIONS



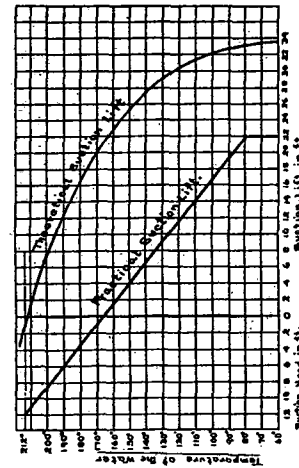
TYPICAL RADIATOR CONNECTIONS



NOTES—In making radiator connections allowance must be made for expansion. All branch connections to pitch down at least 1" in 5'-0" in direction of arrows. Automatic valves or traps plugged with grease or dirt can be cleaned in gasoline.

SAFETY VALVE SIZES. LOW PRESSURE BOILERS, A. S. M. E., STD.

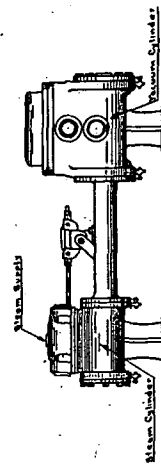
Up to 3.25 sq. ft. Grate = $1\frac{1}{4}"$ 12.51 to 17.75 sq. ft. Grate = $3"$
 3.26 to 4.50 sq. ft. Grate = $1\frac{1}{2}"$ 17.76 to 24.00 sq. ft. Grate = $3\frac{1}{2}"$
 4.51 to 8.00 sq. ft. Grate = $2"$ Over 24 sq. ft. Grate = 2 Valves
 8.01 to 12.50 sq. ft. Grate = $2\frac{1}{2}"$



Altitude	Barometric Pressure	Boiling Point of Water
Sea Level	30.00 in.	212° F.
1000 ft.	29.92 in.	211.9° F.
2000 ft.	29.84 in.	211.8° F.
3000 ft.	29.76 in.	211.7° F.
4000 ft.	29.68 in.	211.6° F.
5000 ft.	29.60 in.	211.5° F.
6000 ft.	29.52 in.	211.4° F.
7000 ft.	29.44 in.	211.3° F.
8000 ft.	29.36 in.	211.2° F.
9000 ft.	29.28 in.	211.1° F.
10000 ft.	29.20 in.	211.0° F.

Pump suction lifts at various temperatures and altitudes, and conversion table, inches of mercury to head of water in feet.

Height in Feet	Height in Inches	Height in Feet	Height in Inches
1	12	11	132
2	24	12	144
3	36	13	156
4	48	14	168
5	60	15	180
6	72	16	192
7	84	17	204
8	96	18	216
9	108	19	228
10	120	20	240
11	132	21	252
12	144	22	264
13	156	23	276
14	168	24	288
15	180	25	300
16	192	26	312
17	204	27	324
18	216	28	336
19	228	29	348
20	240	30	360



SIZE PUMP		CAPACITY		SIZE OPENINGS			APPROX. SPACE	
1/2" Dia. of Suction Port	1/2" Dia. of Discharge Port	1/2" Dia. of Suction Port	1/2" Dia. of Discharge Port	1/2" Dia. of Suction Port	1/2" Dia. of Discharge Port	1/2" Dia. of Suction Port	1/2" Dia. of Discharge Port	
10	10	10	10	10	10	10	10	
15	15	15	15	15	15	15	15	
20	20	20	20	20	20	20	20	
25	25	25	25	25	25	25	25	
30	30	30	30	30	30	30	30	
35	35	35	35	35	35	35	35	
40	40	40	40	40	40	40	40	
45	45	45	45	45	45	45	45	
50	50	50	50	50	50	50	50	
55	55	55	55	55	55	55	55	
60	60	60	60	60	60	60	60	
65	65	65	65	65	65	65	65	
70	70	70	70	70	70	70	70	
75	75	75	75	75	75	75	75	
80	80	80	80	80	80	80	80	
85	85	85	85	85	85	85	85	
90	90	90	90	90	90	90	90	
95	95	95	95	95	95	95	95	
100	100	100	100	100	100	100	100	
105	105	105	105	105	105	105	105	
110	110	110	110	110	110	110	110	
115	115	115	115	115	115	115	115	
120	120	120	120	120	120	120	120	
125	125	125	125	125	125	125	125	
130	130	130	130	130	130	130	130	
135	135	135	135	135	135	135	135	
140	140	140	140	140	140	140	140	
145	145	145	145	145	145	145	145	
150	150	150	150	150	150	150	150	
155	155	155	155	155	155	155	155	
160	160	160	160	160	160	160	160	
165	165	165	165	165	165	165	165	
170	170	170	170	170	170	170	170	
175	175	175	175	175	175	175	175	
180	180	180	180	180	180	180	180	
185	185	185	185	185	185	185	185	
190	190	190	190	190	190	190	190	
195	195	195	195	195	195	195	195	
200	200	200	200	200	200	200	200	
205	205	205	205	205	205	205	205	
210	210	210	210	210	210	210	210	
215	215	215	215	215	215	215	215	
220	220	220	220	220	220	220	220	
225	225	225	225	225	225	225	225	
230	230	230	230	230	230	230	230	
235	235	235	235	235	235	235	235	
240	240	240	240	240	240	240	240	
245	245	245	245	245	245	245	245	
250	250	250	250	250	250	250	250	
255	255	255	255	255	255	255	255	
260	260	260	260	260	260	260	260	
265	265	265	265	265	265	265	265	
270	270	270	270	270	270	270	270	
275	275	275	275	275	275	275	275	
280	280	280	280	280	280	280	280	
285	285	285	285	285	285	285	285	
290	290	290	290	290	290	290	290	
295	295	295	295	295	295	295	295	
300	300	300	300	300	300	300	300	
305	305	305	305	305	305	305	305	
310	310	310	310	310	310	310	310	
315	315	315	315	315	315	315	315	
320	320	320	320	320	320	320	320	
325	325	325	325	325	325	325	325	
330	330	330	330	330	330	330	330	
335	335	335	335	335	335	335	335	
340	340	340	340	340	340	340	340	
345	345	345	345	345	345	345	345	
350	350	350	350	350	350	350	350	
355	355	355	355	355	355	355	355	
360	360	360	360	360	360	360	360	
365	365	365	365	365	365	365	365	
370	370	370	370	370	370	370	370	
375	375	375	375	375	375	375	375	
380	380	380	380	380	380	380	380	
385	385	385	385	385	385	385	385	
390	390	390	390	390	390	390	390	
395	395	395	395	395	395	395	395	
400	400	400	400	400	400	400	400	
405	405	405	405	405	405	405	405	
410	410	410	410	410	410	410	410	
415	415	415	415	415	415	415	415	
420	420	420	420	420	420	420	420	
425	425	425	425	425	425	425	425	
430	430	430	430	430	430	430	430	
435	435	435	435	435	435	435	435	
440	440	440	440	440	440	440	440	
445	445	445	445	445	445	445	445	
450	450	450	450	450	450	450	450	
455	455	455	455	455	455	455	455	
460	460	460	460	460	460	460	460	
465	465	465	465	465	465	465	465	
470	470	470	470	470	470	470	470	
475	475	475	475	475	475	475	475	
480	480	480	480	480	480	480	480	
485	485	485	485	485	485	485	485	
490	490	490	490	490	490	490	490	
495	495	495	495	495	495	495	495	
500	500	500	500	500	500	500	500	
505	505	505	505	505	505	505	505	
510	510	510	510	510	510	510	510	
515	515	515	515	515	515	515	515	
520	520	520	520	520	520	520	520	
525	525	525	525	525	525	525	525	
530	530	530	530	530	530	530	530	
535	535	535	535	535	535	535	535	
540	540	540	540	540	540	540	540	
545	545	545	545	545	545	545	545	
550	550	550	550	550	550	550	550	
555	555	555	555	555	555	555	555	
560	560	560	560	560	560	560	560	
565	565	565	565	565	565	565	565	
570	570	570	570	570	570	570	570	
575	575	575	575	575	575	575	575	
580	580	580	580	580	580	580	580	
585	585	585	585	585	585	585	585	
590	590	590	590	590	590	590	590	
595	595	595	595	595	595	595	595	
600	600	600	600	600	600	600	600	
605	605	605	605	605	605	605	605	
610	610	610	610	610	610	610	610	
615	615	615	615	615	615	615	615	
620	620	620	620	620	620	620	620	
625	625	625	625	625	625	625	625	
630	630	630	630	630	630	630	630	
635	635	635	635	635	635	635	635	
640	640	640	640	640	640	640	640	
645	645	645	645	645	645	645	645	
650	650	650	650	650	650	650	650	
655	655	655	655	655	655	655	655	
660	660	660	660	660	660	660	660	
665	665	665	665	665	665	665	665	
670	670	670	670	670	670	670	670	
675	675	675	675	675	675	675	675	
680	680	680	680	680	680	680	680	
685	685	685	685	685	685	685	685	
690	690	690	690	690	690	690	690	
695	695	695	695	695	695	695	695	
700	700	700	700	700	700	700	700	
705	705	705	705	705	705	705	705	
710	710	710	710	710	710	710	710	
715	715	715	715	715	715	715	715	
720	720	720	720	720	720	720	720	
725	725	725	725	725	725	725	725	
730	730	730	730	730	730	730	730	
735	735	735	735	735	735	735	735	
740	740	740	740	740	740	740	740	
745	745	745	745	745	745	745	745	
750	750	750	750	750	750	750	750	
755	755	755	755	755	755	755	755	
760	760	760	760	760	760	760	760	
765	765	765	765	765	765	765	765	
770	770	770	770	770	770	770	770	
775	775	775	775	775	775	775	775	
780	780	780	780	780	780	780	780	
785	785	785	785	785	785	785	785	
790	790	790	790	790	790	790	790	
795	795	795	795	795	795	795	795	
800	800	800	800	800	800	800	800	
805	805	805	805	805	805	805	805	
810	810	810	810	810	810	810	810	
815	815	815	815	815	815	815	815	
820	820	820	820	820	820	820	820	
825	825	825	825	825	825	825	825	
830	830	830	830	830	830	830	830	
835	835	835	835	835	835	835	835	
840	840	840	840	840	840	840	840	
845	845	845	845	845	845	845	845	
850	850	850	850	850	850	850	850	
855	855	855	855	855	855	855	855	
860	860	860	860	860	860	860	860	
865	865	865	865	865	865	865	865	
870	870	870	870	870	870	870	870	
875	875	875	875	875	875	875	875	
880	880	880	880	880	880	880	880	
885	885	885	885	885	885	885	885	
890	890	890	890	890	890	890	890	
895	895	895	895	895	895	895	895	
900	900	900	900	900	900	900	900	
905	905	905	905	905	905	905	905	
910	910	910	910	910	910	910	910	
915	915	915	9					

PROPERTIES OF SATURATED STEAM

Vacuum in ins. of Mercury or Gage Pres. in lbs.	Absolute Pressure in lbs. per sq. in.	Temperature in Deg. fahr.	Total Heat above 32° fahr. B.t.u. in the Water	Latent Heat of the Steam in B.t.u.	Volume in cu. ft. of 1 lb. of Steam
27.88	1.	101.83	69.8	1104.4	1034.6
25.85	2.	126.15	94.0	1115.0	1021.0
23.81	3.	141.52	109.4	1121.6	1012.3
21.78	4.	153.01	120.9	1126.5	1005.7
19.74	5.	162.28	130.1	1130.5	1000.3
17.70	6.	170.06	137.9	1133.7	995.8
15.67	7.	176.85	144.7	1136.5	991.8
13.63	8.	182.86	150.8	1139.0	988.2
11.60	9.	188.27	156.2	1141.1	985.0
9.56	10.	193.22	161.1	1143.1	982.0
7.52	11.	197.75	165.7	1144.9	979.2
5.49	12.	201.96	169.9	1146.5	976.6
3.45	13.	205.87	173.8	1148.0	974.2
1.42	14.	209.55	177.5	1149.4	971.9
0.00	14.70	212.00	180.0	1150.4	970.4
0.3	15.	213.00	181.0	1150.7	969.7
1.3	16.	216.3	184.4	1152.0	967.6
2.3	17.	219.4	187.5	1153.1	965.6
3.3	18.	222.4	190.5	1154.2	963.7
4.3	19.	225.2	193.4	1155.2	961.8
5.3	20.	228.0	196.1	1156.2	960.0
6.3	21.	230.6	198.8	1157.1	958.3
7.3	22.	233.1	201.3	1158.0	956.7
8.3	23.	235.5	203.8	1158.8	955.1
9.3	24.	237.8	206.1	1159.6	953.5
10.3	25.	240.1	208.4	1160.4	952.0
15.3	30.	250.3	218.8	1163.9	945.1
20.3	35.	259.3	227.3	1166.8	938.9
25.3	40.	267.3	236.1	1169.4	933.3
31.3	46.	275.8	244.8	1172.0	927.2
35.3	50.	281.0	250.1	1173.6	923.5
41.3	56.	288.2	257.5	1175.7	918.2
45.3	60.	292.7	262.1	1177.0	914.9
51.3	66.	299.0	268.5	1178.8	910.2
61.3	76.	308.5	278.3	1181.4	903.0
71.3	86.	317.1	287.2	1183.6	896.4
81.3	96.	324.9	295.3	1185.6	890.3
90.3	105.	331.4	302.0	1187.2	885.2
100.3	115.	338.1	309.0	1188.8	879.8
125.3	140.	353.1	324.6	1192.2	867.6
140.3	155.	361.1	332.9	1194.0	861.0
150.3	165.	366.1	338.2	1195.0	856.8
165.3	180.	373.1	345.6	1196.4	850.8
175.3	190.	377.6	350.4	1197.3	846.9
200.3	215.	388.0	361.4	1199.2	837.9

USEFUL DATA

Diameter	× 3.1416	= Circumference
Circumference	× .3183	= Diameter
Diameter ²	× .7854	= Area of circle
Area of Circle	× 1.2732	= Area of circumscribed square
Area of Circle	× .63662	= Area of inscribed square
Dia. of circle	× .88623	= Side of equal square
Dia. of circle	× .7071	= Side of inscribed square
Circumference of circle	× 1.1284	= Perimeter of equal square
Side of square	× 1.4142	= Dia. of circumscribed circle
Side of square	× 1.1284	= Dia. of equal circle
Perimeter of square	× .88623	= Circumference of equal circle
Diameter ²	× 3.1416	= Surface of sphere
Diameter ³	× .5236	= Volume of sphere
Dia. of sphere	× .806	= Dimensions of equal cube
Dia. of sphere	× .6667	= Length of equal cylinder
Area of base	× 1/3 height	= Volume of pyramid or cone
Base	× 1/3 height	= Area of triangle
Radius	× 1.1547	= Side of inscribed cube
Sq. ins.	× 1.2732	= Circular inches
Sq. ins.	× .00695	= Sq. ft.
Sq. ft.	× .111	= Sq. yd.
Sq. yds.	× .0002066	= Acres
Cu. in.	× .00058	= Cu. ft.
Cu. ft.	× .03704	= Cu. yd.
Cu. in.	× .004329	= U. S. gal.
Cu. ft.	× 7.4805	= U. S. gal.
Cu. in.	× .000466	= U. S. bu.
Cu. ft.	× .8036	= U. S. bu.
U. S. bu.	× 2150.42	= Cu. in.
U. S. bu.	× 1.242	= Cu. ft.
U. S. bu.	× .046	= Cu. yd.
U. S. gal.	× 231.	= Cu. in.
U. S. gal.	× .13368	= Cu. ft.
Cu. in. water	× .36127	= Pounds (avoirdupois)
Cu. ft. water	× 62.4283	= Pounds (avoirdupois)
U. S. gals. water	÷ 268.8	= Tons
Column of water 1" dia. x 12" high		= .34 lb. (avoirdupois)
Cu. in.	× .263	= Lb. Av. Cast Iron
Cu. in.	× .281	= Lb. Av. Wrought Iron
Cu. in.	× .283	= Lb. Av. Cast Steel
Cu. in.	× .3225	= Lb. Av. Copper
Cu. in.	× .3037	= Lb. Av. Brass
Cu. in.	× .26	= Lb. Av. Zinc
Cu. in.	× .4103	= Lb. Av. Lead
Cu. in.	× .2636	= Lb. Av. Tin
Cu. in.	× .4908	= Lb. Av. Mercury
12 × weight of pine pattern		= Iron casting
13 × weight of pine pattern		= Brass casting
14 × weight of pine pattern		= Lead casting

VELOCITY OF STEAM

To find the velocity of steam multiply the condensation in pounds by the volume in cu. ft. corresponding to the pressure, which gives volume of steam passing through the pipe per hour. Dividing this product by 3600 times the area of the pipe in sq. ft. gives velocity in ft. per second.

SPECIFIC HEAT OF BODIES

Material	Specific Heat	Material	Specific Heat	Material	Specific Heat
Cast Iron.....	0.12983	Gold.....	0.03244	Glass.....	0.19768
Wrought Iron....	0.11379	Platinum.....	0.03243	Burnt Clay.....	0.18500
Lime.....	0.09555	Lead.....	0.03140	Brickwood.....	0.20000
Copper.....	0.09515	Bismuth.....	0.03084	Water at 32°.....	1.00000
Brass.....	0.09391	Nickel.....	0.10860	Alcohol (S.G. 793).....	0.62200
Silver.....	0.05701	Ice.....	0.50400	Petroleum.....	0.43400
Tin.....	0.05695	Coal.....	0.27770	Olive Oil.....	0.30960
Mercury.....	0.03332	Coke.....	0.20085	Air.....	0.2415*

*W. H. CARRIER

SPECIFIC GRAVITY OF BODIES

Body	Specific Gravity	Weight per Cu. Ft. in Lb.
Water.....	1.00	62.5
Aluminum.....	2.50	156.3
Tin (cast).....	7.29	455.6
Steel.....	7.84	490.0
Cast Iron.....	7.21	450.6
Wrought Iron.....	7.68	480.0
Brass.....	8.38	523.8
Copper.....	8.79	549.4
Lead (cast).....	11.35	709.4
Mercury.....	13.60	850.0
Platinum.....	21.50	1343.8

DECIMAL EQUIVALENTS OF FRACTIONS

Fraction	Dec. Equiv.	Fraction	Dec. Equiv.	Fraction	Dec. Equiv.	Fraction	Dec. Equiv.
1-64	0.015625	17-64	0.265625	33-64	0.515625	49-64	0.765625
1-32	0.031250	9-32	0.281250	17-32	0.531250	25-32	0.781250
3-64	0.046875	19-64	0.296875	35-64	0.546875	51-64	0.796875
1-16	0.062500	5-16	0.312500	9-16	0.562500	13-16	0.812500
5-64	0.078125	21-64	0.328125	37-64	0.578125	53-64	0.828125
3-32	0.093750	11-32	0.343750	19-32	0.593750	27-32	0.843750
7-64	0.109375	23-64	0.359375	39-64	0.609375	55-64	0.859375
1-8	0.125000	3-8	0.375000	5-8	0.625000	7-8	0.875000
9-64	0.140625	25-64	0.390625	41-64	0.640625	57-64	0.890625
5-32	0.156250	13-32	0.406250	21-32	0.656250	29-32	0.906250
11-64	0.171875	27-64	0.421875	43-64	0.671875	59-64	0.921875
3-16	0.187500	7-16	0.437500	11-16	0.687500	15-16	0.937500
13-64	0.203125	29-64	0.453125	45-64	0.703125	61-64	0.953125
7-32	0.218750	15-32	0.468750	23-32	0.718750	31-32	0.968750
15-64	0.234375	31-64	0.484375	47-64	0.734375	63-64	0.984375
1-4	0.250000	1-2	0.500000	3-4	0.750000	1-	1.000000

SQUARE FEET OF SURFACE PER LINEAL FOOT OF PIPE

ON ALL LENGTHS OVER 1 FT., FRACTIONS LESS THAN TENTHS ARE ADDED TO OR DROPPED
SIZE OF PIPE

Length of Pipe	1/4	1/2	3/4	1	1 1/4	1 1/2	2	2 1/2	3	4	5	6	7	8
1	.275	.346	.434	.494	.622	.753	.916	1.175	1.455	1.739	2.022	2.306	2.590	2.874
2	.5	.7	.9	1.1	1.2	1.5	1.8	2.4	2.9	3.5	4.1	4.7	5.3	5.9
3	.8	1.1	1.3	1.5	1.9	2.3	2.7	3.5	4.4	5.2	6.0	6.8	7.6	8.4
4	1.1	1.4	1.7	2.0	2.5	3.0	3.6	4.7	5.8	6.7	7.7	8.7	9.7	10.7
5	1.4	1.7	2.2	2.4	3.1	3.8	4.6	5.8	7.3	8.2	9.2	10.2	11.2	12.2
6	1.6	2.1	2.6	2.9	3.7	4.5	5.5	7.0	8.7	10.2	12.1	14.0	15.8	17.6
7	1.9	2.4	3.0	3.4	4.4	5.3	6.4	8.2	10.2	12.1	14.0	16.0	18.0	20.0
8	2.2	2.8	3.5	3.9	5.0	6.0	7.3	9.4	11.6	13.9	16.1	18.4	20.7	23.0
9	2.5	3.1	3.9	4.4	5.6	6.8	8.2	10.6	13.1	15.7	18.2	20.7	23.2	25.7
10	2.7	3.5	4.3	4.9	6.2	7.5	9.1	11.8	14.6	17.4	20.2	23.0	25.8	28.6
11	3.0	3.8	4.8	5.4	6.8	8.3	10.1	12.9	16.0	19.1	22.1	25.1	28.1	31.1
12	3.3	4.1	5.2	5.9	7.5	9.1	11.1	14.1	17.4	20.9	24.2	27.5	30.8	34.1
13	3.6	4.5	5.6	6.4	8.1	9.8	11.9	15.3	18.9	22.6	26.2	29.8	33.4	37.0
14	3.8	4.8	6.1	6.9	8.7	10.5	12.8	16.5	20.3	24.3	28.1	31.9	35.7	39.5
15	4.1	5.2	6.5	7.4	9.3	11.3	13.7	17.6	21.8	26.1	30.3	34.5	38.7	42.9
16	4.4	5.5	6.9	7.9	10.1	12.2	14.6	18.8	23.2	27.8	32.3	36.7	41.1	45.5
17	4.7	5.9	7.4	8.4	10.6	12.8	15.5	20.0	24.7	29.5	34.2	38.9	43.6	48.3
18	5.0	6.2	7.8	8.9	11.2	13.5	16.5	21.2	26.2	31.3	36.0	40.7	45.4	50.1
19	5.2	6.6	8.3	9.4	11.8	14.3	17.4	22.3	27.6	33.1	38.4	43.7	48.9	54.2
20	5.5	6.9	8.7	9.9	12.5	15.1	18.3	23.5	29.1	34.8	40.4	45.9	51.4	56.9
21	5.8	7.3	9.1	10.4	13.1	15.8	19.2	24.7	30.5	36.5	42.4	48.1	53.8	59.5
22	6.1	7.6	9.6	10.9	13.7	16.5	20.2	25.9	32.1	38.3	44.4	50.4	56.4	62.4
23	6.3	8.0	10.1	11.3	14.3	17.3	21.1	27.0	33.5	40.0	46.5	52.9	59.3	65.7
24	6.6	8.3	10.4	11.9	14.9	18.0	22.0	28.2	34.9	41.7	48.5	55.2	61.9	68.6
25	6.9	8.6	10.9	12.3	15.6	18.8	22.9	29.3	36.3	43.5	50.5	57.4	64.3	71.2
26	7.1	9.0	11.3	12.8	16.2	19.5	23.8	30.5	37.8	45.2	52.2	59.1	66.0	72.9
27	7.4	9.4	11.7	13.3	16.8	20.3	24.7	31.7	39.3	47.1	54.1	61.0	67.9	74.8
28	7.7	9.7	12.2	13.8	17.4	21.1	25.6	32.9	40.7	48.7	56.0	63.2	70.4	77.6
29	8.0	10.1	12.6	14.3	18.1	21.8	26.6	34.1	42.2	50.4	58.0	65.5	73.0	80.5
30	8.3	10.4	13.1	14.8	18.7	22.5	27.5	35.3	43.6	52.1	60.0	67.7	75.4	83.1
31	8.5	10.7	13.5	15.3	19.3	23.3	28.4	36.4	45.1	53.9	62.0	70.0	77.9	85.8
32	8.8	11.1	13.9	15.8	19.9	24.1	29.3	37.6	46.5	55.6	64.0	72.2	80.4	88.6
33	9.1	11.4	14.3	16.3	20.5	24.8	30.2	38.8	48.1	57.4	66.0	74.4	82.8	91.2
34	9.4	11.7	14.7	16.8	21.2	25.6	31.1	40.0	49.5	59.1	68.0	76.7	85.4	94.1
35	9.6	12.1	15.2	17.3	21.8	26.3	32.1	41.1	50.9	60.8	70.0	79.0	88.0	97.0
36	9.9	12.5	15.6	17.8	22.4	27.0	33.1	42.3	52.4	62.6	72.0	81.3	90.6	100.0
37	10.2	12.8	16.1	18.3	23.0	27.8	33.9	43.5	53.8	64.3	74.0	83.5	93.0	102.5
38	10.5	13.2	16.5	18.8	23.7	28.5	34.8	44.6	55.2	66.0	76.0	85.8	95.7	105.6
39	10.7	13.5	16.9	19.3	24.3	29.3	35.7	45.8	56.7	67.8	78.0	88.0	98.0	108.0
40	11.0	13.8	17.4	19.8	24.9	30.1	36.6	47.1	58.2	69.5	80.0	90.2	100.4	110.6
41	11.3	14.2	17.8	20.3	25.5	30.8	37.6	48.2	59.6	71.3	82.0	92.5	103.0	113.5
42	11.5	14.5	18.2	20.8	26.1	31.6	38.5	49.4	61.1	73.0	84.0	94.8	105.6	116.4
43	11.8	14.9	18.7	21.3	26.8	32.3	39.4	50.6	62.5	74.8	86.0	97.0	108.0	119.0
44	12.1	15.2	19.1	21.8	27.4	33.1	40.3	51.7	64.0	76.5	88.0	99.3	110.6	121.9
45	12.4	15.6	19.5	22.2	28.0	33.8	41.2	52.9	65.5	78.2	90.0	101.6	113.2	124.8
46	12.7	15.9	20.0	22.7	28.6	34.6	42.2	54.0	67.0	80.0	92.0	103.8	115.6	127.4
47	12.9	16.3	20.4	23.2	29.2	35.3	43.1	55.2	68.4	81.7	94.0	106.0	117.9	129.8
48	13.2	16.6	20.8	23.7	29.9	36.1	43.9	56.4	69.8	83.5	96.0	108.0	120.0	132.0
49	13.5	17.0	21.3	24.2	30.5	36.8	44.8	57.6	71.2	85.1	98.0	110.5	123.0	135.0
50	13.8	17.3	21.7	24.7	31.1	37.6	45.8	58.7	72.7	87.0	100.0	112.8	125.6	138.4

TABLE SHOWING EXPANSION OF WROUGHT IRON PIPE

Initial	Increase in Length per 100 Ft. when Heated to									
Temperature	160°	180°	200°	212°	228°	240°	250°	259°	267°	274°
Zero, in.	1.28	1.44	1.60	1.69	1.82	1.92	2.00	2.07	2.13	2.20
32° in.	1.02	1.18	1.34	1.43	1.56	1.66	1.74	1.81	1.87	1.94
64° in.	0.77	0.93	1.09	1.18	1.31	1.41	1.49	1.56	1.61	1.69
	Hot Water			Water Boils	5 lb.	10 lb.	15 lb.	20 lb.	25 lb.	30 lb.

Wrought iron pipe expands, in inches, per 100 ft., 4/5 of the increase in temperature of steam or water it is subjected to, over the temperature at the time of installation, divided by 100.

Example—Temperature when installed, 32°, 10 lb. pressure=240°, difference 208°, 4/5 of which equals 1.66 in. expansion per 100 ft.

WROUGHT IRON WELDED STEAM, GAS, AND WATER PIPE
TABLE OF STANDARD DIMENSIONS

Diameter			Thick- ness	Circumference		Transverse Areas			Length of Pipe per Sq. Ft. of		Length of Pipe Contain- ing One Cu. Ft.	Nomi- nal Weight Per Foot.	No. of Threads Per Inch of Screw	Tap Drill
Nominal Internal Inches	Actual			Inter- nal Inches	Exter- nal Inches	Exter- nal Sq. In.	Inter- nal Sq. In.	Metal Sq. In.	Exter- nal Surface Feet	Inter- nal Surface Feet				
	Inches	Inches												
1/4	0.405	0.27	0.068	1.272	0.848	0.129	0.0573	0.0717	9.44	14.15	2513.	0.241	27	1/4
1/4	0.54	0.364	0.088	1.696	1.144	0.229	0.1041	0.1249	7.075	10.49	1383.3	0.42	18	1/4
1/4	0.675	0.494	0.091	2.121	1.552	0.358	0.1917	0.1663	5.657	7.73	751.2	0.559	18	1/4
1/4	0.84	0.623	0.109	2.639	1.957	0.554	0.3048	0.2492	4.547	6.13	472.4	0.837	14	1/4
1/2	1.05	0.824	0.113	3.299	2.589	0.866	0.5333	0.3327	3.637	4.635	270.	1.115	14	1/2
1	1.315	1.048	0.134	4.131	3.292	1.358	0.8626	0.4954	2.904	3.645	166.9	1.668	11 1/2	1 1/4
1 1/2	1.66	1.38	0.14	5.215	4.335	2.164	1.496	0.668	2.301	2.768	96.25	2.244	11 1/2	1 1/2
1 1/2	1.9	1.611	0.145	5.969	5.061	2.835	2.038	0.797	2.01	2.371	70.66	2.678	11 1/2	1 1/2
2	2.375	2.067	0.154	7.461	6.494	4.43	3.356	1.074	1.608	1.848	42.91	3.609	11 1/2	2 1/4
2 1/2	2.875	2.468	0.204	9.032	7.753	6.492	4.784	1.708	1.328	1.547	30.1	5.739	8	2 1/2
3	3.5	3.067	0.217	10.996	9.636	9.621	7.388	2.243	1.091	1.245	19.5	7.536	8	3 1/4
3 1/2	4.	3.548	0.226	12.566	11.146	12.566	9.887	2.679	0.955	1.077	14.57	9.001	8	3 1/2
4	4.5	4.026	0.237	14.137	12.648	15.904	12.73	3.174	0.849	0.949	11.31	10.665	8	4 1/2
4 1/2	5.	4.508	0.246	15.708	14.162	19.635	15.961	3.674	0.764	0.848	9.02	12.34	8	4 1/2
5	5.563	5.045	0.259	17.477	15.849	24.306	19.99	4.316	0.687	0.757	7.2	14.502	8	5 1/2
6	6.625	6.065	0.28	20.813	19.054	34.472	28.888	5.584	0.577	0.63	4.98	18.762	8	6 1/2
7	7.625	7.023	0.301	23.955	22.063	45.664	38.738	6.926	0.501	0.544	3.72	23.271	8	7 1/2
8	8.625	7.982	0.322	27.096	25.076	58.426	50.04	8.386	0.443	0.478	2.88	28.177	8	8 1/2
9	9.625	8.937	0.344	30.238	28.076	72.76	62.73	10.03	0.397	0.427	2.29	33.701	8	9 1/2
10	10.75	10.019	0.366	33.772	31.477	90.763	78.839	11.924	0.355	0.382	1.82	40.065	8	10 1/2

CIRCUMFERENCE AND AREAS OF CIRCLES

Dia.	Circumference	Area	Dia.	Circumference	Area	Dia.	Circumference	Area
1/4	3.927	0.0123	16	50.265	201.06	54	169.646	2290.2
1/4	7.854	0.0491	17	51.836	213.82	55	172.788	2375.8
1/4	1.1781	0.1104	18	53.407	226.98	56	175.929	2463.0
1/4	1.5708	0.1963	19	54.978	240.52	57	179.071	2551.7
1/4	1.9635	0.3067	20	56.549	254.46	58	182.212	2642.0
1/4	2.3562	0.4417	21	58.119	268.80	59	185.354	2733.9
1/4	2.7489	0.6013	22	59.690	283.52	60	188.496	2827.4
1	3.1416	0.7854	23	61.261	298.64	61	191.637	2922.4
1	3.5343	0.9940	24	62.832	314.16	62	194.779	3019.0
1	3.9270	1.227	25	64.403	330.06	63	197.920	3117.2
1	4.3197	1.484	26	65.973	346.36	64	201.062	3216.9
1	4.7124	1.767	27	67.544	363.05	65	204.204	3318.3
1	5.1051	2.073	28	69.115	380.13	66	207.345	3421.2
1	5.4978	2.405	29	70.686	397.60	67	210.487	3525.6
1	5.8905	2.761	30	72.257	415.47	68	213.628	3631.6
2	6.2832	3.141	31	73.827	433.73	69	216.770	3739.2
2	7.0686	3.976	32	75.398	452.39	70	219.911	3848.4
2	7.8540	4.908	33	76.969	471.43	71	223.053	3959.2
2	8.6394	5.939	34	78.540	490.87	72	226.195	4071.5
2	9.4248	7.068	35	80.111	510.70	73	229.336	4185.3
3	10.210	8.295	36	81.682	530.93	74	232.478	4300.8
3	10.996	9.621	37	83.253	551.55	75	235.619	4417.8
3	11.781	11.044	38	84.823	572.55	76	238.761	4536.4
3	12.566	12.566	39	86.394	593.93	77	241.903	4656.0
3	13.351	14.137	40	87.965	615.75	78	245.044	4778.3
4	14.137	15.904	41	89.536	637.93	79	248.186	4901.6
4	15.708	19.635	42	91.107	660.52	80	251.327	5026.5
4	17.279	23.758	43	92.678	683.50	81	254.469	5153.0
4	18.850	28.274	44	94.249	706.86	82	257.611	5281.0
5	20.420	33.183	45	95.820	730.60	83	260.752	5410.6
5	21.991	38.484	46	97.391	754.76	84	263.894	5541.7
5	23.562	44.178	47	98.962	779.33	85	267.035	5674.5
6	25.133	50.265	48	100.533	804.24	86	270.177	5808.8
6	26.704	56.745	49	102.104	829.50	87	273.319	5944.6
6	28.274	63.617	50	103.675	855.30	88	276.460	6082.1
6	29.845	70.882	51	105.246	881.55	89	279.602	6221.1
7	31.416	78.54	52	106.817	908.25	90	282.743	6361.7
7	32.987	86.59	53	108.388	935.40	91	285.885	6503.8
7	34.558	95.03	54	109.959	962.99	92	289.027	6647.6
8	36.128	103.86	55	111.530	990.60	93	292.168	6792.9
8	37.699	113.09	56	113.101	1018.6	94	295.310	6939.7
8	39.270	122.71	57	114.672	1047.0	95	298.451	7088.2
9	40.841	132.73	58	116.243	1075.2	96	301.593	7238.2
9	42.412	143.13	59	117.814	1103.9	97	304.734	7389.8
9	43.982	153.93	60	119.385	1132.9	98	307.876	7542.9
10	45.553	165.13	61	120.956	1162.2	99	311.018	7697.7
10	47.124	176.71	62	122.527	1191.8			
10	48.695	188.69	63	124.098	1221.6			

GENERAL DATA

1 Calorie	=	3.968 B. t. u.
1 B. t. u.	=	0.252 Calorie
1 lb. per sq. in.	=	703.08 kilogrammes per m ²
1 Kilogramme per m ²	=	0.00142 lbs. per sq. in.
1 Calorie per m ²	=	0.3687 B. t. u. per sq. ft.
1 B. t. u. per sq. ft.	=	2.712 calories per m ²
1 Calorie per m ² per deg difference cent.	=	0.2048 B. t. u. per sq. ft. per deg. difference fahr.
1 B. t. u. per sq. ft. per deg. difference fahr.	=	4.882 Calories per m ² per deg. difference cent.
1 B. t. u. per lb.	=	0.556 Calories per kilog.
1 Calorie per kilog.	=	1.8 B. t. u. per lb.
1 Litre of Coke at 26.3 lb. per cu. ft.	=	0.93 lbs.
1 lb. of Coke at 26.3 lb. per cu. ft.	=	1.076 litres.
Water expands in bulk from 40 deg. to 212 deg.	=	One twenty-third.

A cubic inch of water evaporated under ordinary atmospheric pressure is converted into 1 cubic foot of steam (approximately).

WEIGHTS

1 cu. in. of Cast Iron	weighs	0.260 lb.
1 cu. in. of Wrought Iron	weighs	0.280 lb.
1 cu. in. of Water	weighs	0.036 lb.
1 U. S. gal.	weighs	8.330 lb.
1 Imperial gal.	weighs	10.000 lb.
1 U. S. gal.	equals	231.000 cu. in.
1 Imperial gal.	equals	277.274 cu. in.
1 cu. ft. of Water	equals	7.480 U. S. gal.
1 lb. of Steam	equals	27.222 cu. ft.
1 lb. of Air	equals	13.817 cu. ft.

WEIGHTS AND MEASURES

SURVEYORS MEASURE

7.92 in.	1 link
25 links	1 rod 4 rods
10 sq. chains or 160 sq. rods	1 acre
640 acres	1 sq. mile
36 sq. miles (6 miles sq.)	1 township

CUBIC MEASURE

1728 cu. in.	1 cu. ft.	128 cu. ft.	1 cord (wood)
27 cu. ft.	1 cu. yd.	40 c. f.	1 ton (shpg)
2150.42 cu. in.			1 standard bu.
231 cu. in.			1 U. S. standard gal.
1 cu. ft.			about 4/5 of a bu.

METRIC EQUIVALENTS—LINEAR MEASURE

1 centimeter	0.3937 in.	1 in.	2.54 centimeters
1 decimeter	3.937 in.		0.328 ft.
1 ft.			3.048 decimeters
1 meter	39.37 in.		1.0936 yards
1 yd.			0.9144 meter
1 dekameter	1.9884 rods	1 rd.	0.5029 dekameter
1 kilometer	0.62137 m.	1 m.	1.6093 kilometers

SQUARE MEASURE

1 sq. centimeter	0.1550 sq. in.	1 sq. in.	6.452 sq. centimeters
1 sq. decimeter	0.1076 sq. ft.	1 sq. ft.	9.2903 sq. decimeters
1 sq. meter	1.196 sq. yd.	1 sq. yd.	0.8361 sq. m ²
1 are	3.954 sq. rods	1 sq. rd.	0.2529 are
1 hectare	2.47 acres	1 acre	0.4047 hectare
1 sq. kilometer	0.386 sq. m.	1 sq. m.	2.59 sq. kilometers

WEIGHTS

1 gram	0.03527 ounce	1 oz.	28.35 grams
1 kilogram	2.2046 lbs.	1 lb.	0.4536 kilogram
1 metric ton	1.1023 English tons	1 English ton	0.9072 metric ton

APPROXIMATE METRIC EQUIVALENTS

1 decimeter	4 in.	1 liter	1.06 qts. liquid
1 meter	1.1 yds.		0.9 qt. dry
1 kilometer	5/8 of a mile	1 hektoliter	2 1/2 bu.
1 hectare	2 1/2 acres	1 kilogram	2 1/4 lb.
1 stere, or cu. meter	1/4 of a cord	1 metric ton	2,200 lb.

TROY WEIGHT

24 grains	1 pwt.
20 pwt.	1 oz.
Used for weighing gold, silver and jewels.	

APOTHECARIES WEIGHT

20 grains	1 scruple	8 drams	1 oz.
3 scruples	1 dram	12 oz.	1 lb.
Ounce and pound are the same as in Troy Weight.			

AVOIRDUPOIS WEIGHT

27 3/4 grains	1 dram	4 quarters	1 cwt.
16 drams	1 oz.	2,000 lb.	1 short ton
16 oz.	1 lb.	2,240 lb.	1 long ton
25 lb.	1 quarter		

DRY MEASURE

2 pints	1 qt.	4 pecks	1 bu.
8 qts.	1 peck	36 bushels	1 chaldron

LIQUID MEASURE

4 gills	1 pt.	31 1/2 gals.	1 bbl.
2 pts.	1 qt.	2 barrels	1 hogshead
4 qts.	1 gal.		

LONG MEASURE

12 in.	1 ft.	40 rods	1 furlong
3 ft.	1 yd.	8 furlongs	1 sta. mile
5 1/2 yds.	1 rod	3 miles	1 league

CLOTH MEASURE

2 1/4 in.	1 nail	4 quarters	1 yard
4 nails	1 quarter		

SQUARE MEASURE

144 sq. in.	1 sq. ft.	40 sq. rods	1 rood
9 sq. ft.	1 sq. yard	4 roods	1 acre
30 1/4 sq. yd.	1 sq. rod	640 acres	1 sq. mile

METRIC AND ENGLISH MEASURES

MEASURES OF LENGTH

Metric		English
1 metre	=	39.37 in.
.3048 metre	=	3.28 ft.
1 centimetre	=	.3937 in.
2.54 centimetres	=	1 in.
1 millimetre	=	.03937 in. (1/25 in., nearly)
25.4 millimetres	=	1 in.
1 kilometre	=	1093.61 yds.

MEASURES OF SURFACE

1 sq. metre	=	10.764 sq. ft.
.0929 sq. metre	=	1 sq. ft.
1 sq. centimetre	=	.155 sq. in.
6.452 sq. centimetres	=	1 sq. in.
1 sq. millimetre	=	.00155 sq. in.
645.2 sq. millimetres	=	1 sq. in.

MEASURES OF VOLUME

1 cu. metre	=	35.314 cu. ft.
.02832 cu. metre	=	1 cu. ft.
1 cu. decimetre	=	61.023 cu. in.
	=	.0353 cu. ft.
28.32 cu. decimetres	=	1 cu. ft.
16.387 cu. centimetres	=	1 cu. in.
1 cu. centimetre	=	.061 cu. in.

MEASURES OF CAPACITY

		61.023 cu. in.
		.0353 cu. ft.
1 litre = 1 cu. decimetre	=	.2202 gal. (Imperial)
	=	2.202 lb. of water at 62 deg. fahr.
28.317 litres	=	1 cu. ft. (6.25 Imperial gal.)
4.543 litres	=	1 gal. (Imperial)
3.785 litres	=	1 gal. (American)

MEASURES OF WEIGHT

Metric		English
28.35 grammes	=	1 oz. avoirdupois
1 kilogramme	=	2.2046 lb.
.4536 kilogramme	=	1 lb.
1 metric ton	=	.9842 ton of 2240 lb., or
1000 kilogrammes	=	19.68 cwt. or 2204.6 lb.
1.016 metric tons	=	1 ton of 2240 lb.
1016 kilogrammes	=	

MISCELLANEOUS

1 gramme per sq. millimetre	=	1.422 lb. per sq. in.
1 kilogramme per sq. millimetre	=	1422.32 lb. per sq. in.
1 kilogramme per sq. centimetre	=	14.233 lb. per sq. in.
1.0335 kg. per sq. centimetre	=	14.7 lb. per sq. in.
0.070308 kilogramme per sq. centimetre	=	1 lb. per sq. in.

MEASURES OF PRESSURE AND WEIGHT

1 lb. per sq. in.	=	144 lb. per sq. ft.
	=	2.0355 in. of mercury at 32 deg. fahr.
	=	2.0416 in. of mercury at 62 deg. fahr.
	=	2.309 ft. of water at 62 deg. fahr.
	=	27.71 in. of water at 62 deg. fahr.

1 Atmosphere (14.7 lb. per sq. in.)	=	2116.3 lb. per sq. ft.
	=	33.947 ft. of water at 62 deg. fahr.
	=	30 in. of mercury at 62 deg. fahr.
	=	29.922 in. of mercury at 32 deg. fahr.
	=	760 millimetres of mercury at 32 deg. fahr.

1 ft. of Water at 62 deg. fahr.	=	0.433 lb. per sq. in.
	=	62.355 lb. per sq. ft.

1 in. of Mercury at 62 deg. fahr.	=	0.491 lb. or 7.86 oz. per sq. in.
	=	1.132 ft. of water at 62 deg. fahr.
	=	13.58 in. of water at 62 deg. fahr.

WEIGHT OF ONE CUBIC FOOT OF PURE WATER

At 32 deg. fahr. (freezing point)	62.418 lb.
At 39.1 deg. fahr. (maximum density)	62.425 lb.
At 62 deg. fahr. (standard temperature)	62.355 lb.
At 212 deg. fahr. (boiling point, under 1 atmosphere)	59.76 lb.
Imperial gal. = 277.274 cu. in. of water at 62 deg. fahr.	10 lb.
American gal. = 231 cu. in. of water at 62 deg. fahr.	8.3356 lb.

BOILING POINTS OF VARIOUS FLUIDS

	Degrees Fahr.		Degrees Fahr.
Water, Atmospheric Pressure.....	212	Refined Petroleum	316
Alcohol	173	Turpentine	315
Sulphuric Acid	240	Sulphur	570
		Linseed Oil	597

MELTING POINTS OF DIFFERENT METALS

	Degrees Fahr.		Degrees Fahr.
Aluminum	1400	Iron (cast)	2450
Antimony	810	Iron (wrought)	2912
Bismuth	476	Lead	608
Brass	1900	Platinum	3080
Bronze	1692	Silver (pure)	1873
Copper	1996	Steel	2500
Glass	2377	Tin	446
Gold (pure)	2590	Zinc	680

PROPERTIES OF AIR *

Air is a mechanical mixture of various gases, ordinarily considered as consisting of oxygen and nitrogen, but also containing a portion of moisture and carbonic acid, and a very small part of other constituents. The proportion of these components will vary under different conditions, but ordinarily pure dry air is composed as follows, in per cent.:

	By Volume	By Weight
Oxygen	20.9	23.1
Nitrogen	79.1	76.9

The moisture will vary with the humidity of the air, from 0 to 4 per cent, and the carbonic acid will vary with the purity of the air from perhaps 0.03 to 0.30 per cent, or as usually expressed from 3 to 30 parts in 10,000.

Weight of Air

The weight of the air varies with its temperature and barometric pressure and also with the amount of moisture it contains. The weight of one cubic foot of pure dry air expressed in pounds may be determined by the formula

$$W = \frac{2.6982 p}{459.2 + t} \quad (1)$$

where p = absolute pressure in pounds per square inch.
 t = temperature of the air in degrees F.

A convenient formula for expressing the weight of dry air at any conditions of temperature and pressure as used by Frank H. Kneeland¹ is

$$W = \frac{1.3253 b}{459.2 + t} \quad (2)$$

where b = corrected barometer reading in inches of mercury

t = temperature, deg. F.

1.3253 = weight in lbs. of 459.2 cu. ft. of air at 0° F. and 1" barometric pressure.

A formula expressing the weight of humid air is given in the Smithsonian Meteorological Tables as

$$W = \frac{0.080723}{1 + 0.0020389(t - 32)} \times \frac{b - 0.378 e}{29.921} \quad (3)$$

where t = temperature, deg. Fahr.

b = height of barometer in inches of mercury

e = pressure due to vapor in the air in inches of mercury.

According to the latest data the above values should be slightly changed, and we will then have the following formulae as convenient forms for calculating the weight per cubic foot of either dry or moist air.

$$\text{For dry air} \quad W = \frac{0.0028862b}{1 + 0.0021758 t} \quad (4)$$

$$\text{For moist air} \quad W = \frac{0.0028862b - 0.001088 e}{1 + 0.0021758 t} \quad (5)$$

This last gives the weight of a cubic foot of the mixture of air and vapor, either for saturated or partly saturated air.

* From *Fan Engineering*, Buffalo Forge Co.

¹ "Some Experiences with the Pitot Tube on High and Low Velocities," Am. Soc. Mech. Engrs., Dec., 1911.

The weight of the dry air contained in one cubic foot of saturated air may be determined from the formula

$$W = \frac{0.0028862b - 0.002886 e}{1 + 0.0021758 t} \quad (6)$$

The weight of vapor or density in pounds per cubic foot of saturated vapor at temperature t is given by the following:

$$D_s = \frac{S(144 \times 0.4908 e)}{53.35(459.2 + t)} \quad (7)$$

where S is the specific weight of water vapor and may be found as

$$S = 0.6221 + 0.001815 \sqrt{e} + 0.0000051 \sqrt{e^3} \quad (8)$$

The relationship between the temperature and specific weight of vapor is shown by the diagram on this page taken from W. H. Carrier's paper on "Rational Psychrometric Formulae." *

An approximate value for the weight of water vapor contained in one pound of dry air saturated with moisture may be determined from

$$G = \frac{0.624 e}{b - e} \quad (9)$$

It may be noted from the curve that the value of 0.624 for S in the above is only correct at about 70°.

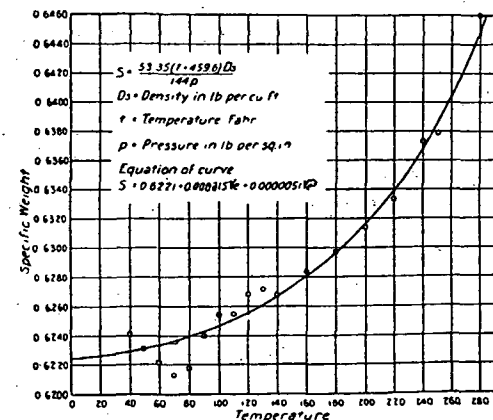


FIG. 1

Specific Weight of Water Vapor

The table No. 1 gives the properties of dry air for various temperatures, and the table No. 2 the properties of saturated air. These are both based on the standard barometric pressure of 29.921 inches.

The table No. 3 giving the weights of saturated and partly saturated air for various barometric and hygrometric conditions will be found especially convenient in making calculations based on other than standard conditions. The weight in pounds per cubic foot of saturated air is given for even barometric pressures and temperatures. The decrement per degree rise in temperature and the increment per 0.1" increase in barometer are also given, thus readily giving the weight of saturated air at any other temperature and pressure. The last column in the table gives the approximate average increment per degree wet-bulb depression which is to be added to the weight of saturated air to obtain the corresponding weight of partly saturated air.

* "Rational Psychrometric Formulae," Am. Soc. Mech. Engrs., Dec., 1911.

TABLE No. 1

PROPERTIES OF DRY AIR
Barometric Pressure 29.921 Inches

Temperature Degrees Fahr.	Weight per Cu. Ft. Pounds	Per Cent. of Volume at 70° F.	B. t. u. Absorbed by One Cu. Ft. Dry Air per Degree F.	Cu. Ft. Dry Air Warmed One Degree per B. t. u.	Temperature Degrees Fahr.	Weight per Cu. Ft. Pounds	Per Cent. of Volume at 70° F.	B. t. u. Absorbed by One Cu. Ft. Dry Air per Degree F.	Cu. Ft. Dry Air Warmed One Degree per B. t. u.
0	.08636	.8680	.02080	48.08	130	.06732	1.1133	.01631	61.32
5	.08544	.8772	.02060	48.55	135	.06675	1.1230	.01618	61.81
10	.08453	.8867	.02039	49.05	140	.06620	1.1320	.01605	62.31
15	.08363	.8962	.02018	49.56	145	.06565	1.1417	.01592	62.82
20	.08276	.9057	.01998	50.05	150	.06510	1.1512	.01578	63.37
25	.08190	.9152	.01977	50.58	160	.06406	1.1700	.01554	64.35
30	.08107	.9246	.01957	51.10	170	.06304	1.1890	.01530	65.36
35	.08025	.9340	.01938	51.60	180	.06205	1.2080	.01506	66.40
40	.07945	.9434	.01919	52.11	190	.06110	1.2270	.01484	67.40
45	.07866	.9530	.01900	52.64	200	.06018	1.2455	.01462	68.41
50	.07788	.9624	.01881	53.17	220	.05840	1.2833	.01419	70.48
55	.07713	.9718	.01863	53.68	240	.05673	1.3212	.01380	72.46
60	.07640	.9811	.01846	54.18	260	.05516	1.3590	.01343	74.46
65	.07567	.9905	.01829	54.68	280	.05367	1.3967	.01308	76.46
70	.07495	1.0000	.01812	55.19	300	.05225	1.4345	.01274	78.50
75	.07424	1.0095	.01795	55.72	350	.04903	1.5288	.01197	83.55
80	.07356	1.0190	.01779	56.21	400	.04618	1.6230	.01130	88.50
85	.07289	1.0283	.01763	56.72	450	.04364	1.7177	.01070	93.46
90	.07222	1.0380	.01747	57.25	500	.04138	1.8113	.01018	98.24
95	.07157	1.0472	.01732	57.74	550	.03932	1.9060	.00967	103.42
100	.07093	1.0570	.01716	58.28	600	.03746	2.0010	.00923	108.35
105	.07030	1.0660	.01702	58.76	700	.03423	2.1900	.00847	118.07
110	.06968	1.0756	.01687	59.28	800	.03151	2.3785	.00782	127.88
115	.06908	1.0850	.01673	59.78	900	.02920	2.5670	.00728	137.37
120	.06848	1.0945	.01659	60.28	1000	.02720	2.7560	.00680	147.07
125	.06790	1.1040	.01645	60.79	1200	.02392	3.1335	.00603	165.83

TABLE No. 2

PROPERTIES OF SATURATED AIR

Weights of Air, Vapor of Water, and Saturated Mixture of Air and Vapor at
Different Temperatures, Under Standard Atmospheric Pressure
of 29.921 Inches of Mercury

Temperature Degrees Fahr.	Vapor Pressure Inches of Mercury	Weight in a Cubic Foot of Mixture			B. t. u. Absorbed by One Cubic Foot Sat. Air per Degree F.	Cubic Feet Sat. Air Warmed One Degree per B. t. u.
		Weight of the Dry Air Pounds	Weight of the Vapor Pounds	Total Weight of the Mixture Pounds		
1	2	3	4	5	6	7
0	.0383	.08625	.000069	.08632	.02082	48.04
10	.0631	.08433	.000111	.08444	.02039	49.05
20	.1030	.08247	.000177	.08265	.01998	50.05
30	.1640	.08063	.000276	.08091	.01955	51.15
40	.2477	.07880	.000409	.07921	.01921	52.06
50	.3625	.07694	.000587	.07753	.01883	53.11
60	.5220	.07506	.000829	.07589	.01852	54.00
70	.7390	.07310	.001152	.07425	.01811	55.22
80	1.0290	.07095	.001576	.07253	.01788	55.93
90	1.4170	.06881	.002132	.07094	.01763	56.72
100	1.9260	.06637	.002848	.06922	.01737	57.57
110	2.5890	.06367	.003763	.06743	.01716	58.27
120	3.4380	.06062	.004914	.06553	.01696	58.98
130	4.5200	.05716	.006357	.06352	.01681	59.50
140	5.8800	.05319	.008140	.06133	.01669	59.92
150	7.5700	.04864	.010310	.05894	.01663	60.14
160	9.6590	.04341	.012956	.05637	.01664	60.10
170	12.2000	.03735	.016140	.05349	.01671	59.85
180	15.2900	.03035	.019940	.05029	.01682	59.45
190	19.0200	.02227	.024465	.04674	.01706	58.80
200	23.4700	.01297	.029780	.04275	.01750	57.15

WEIGHTS OF SATURATED AND PARTLY SATURATED AIR FOR VARIOUS BAROMETRIC AND HYGROMETRIC CONDITIONS--Pounds per Cubic Foot

Barometric Pressure—Inches																					
26				27				28				29				30				Incr's Wt. per 0.1" Rise in Bar.	Approx. Averg Increase in Weight per Degree Wet Bulb Depression
Wt. per Cu. Ft. Saturated Air	Decr's Wt. per Deg. Inc.	Dry Bulb.	Incr's Wt. per 0.1" Rise in Bar.	Wt. per Cu. Ft. Saturated Air	Decr's Wt. per Deg. Inc.	Dry Bulb.	Incr's Wt. per 0.1" Rise in Bar.	Wt. per Cu. Ft. Saturated Air	Decr's Wt. per Deg. Inc.	Dry Bulb.	Incr's Wt. per 0.1" Rise in Bar.	Wt. per Cu. Ft. Saturated Air	Decr's Wt. per Deg. Inc.	Dry Bulb.	Incr's Wt. per 0.1" Rise in Bar.						
0	0.7500	0.0016	0.0029	0.7788	0.0016	0.0029	0.8077	0.0017	0.0029	0.8355	0.0018	0.0029	0.8654	0.0019	0.0029	0.8954	0.0029	0.00015			
10	0.7338	0.0016	0.0028	0.7620	0.0016	0.0028	0.7903	0.0017	0.0028	0.8185	0.0018	0.0028	0.8468	0.0018	0.0028	0.8750	0.0028	0.00016			
20	0.7180	0.0028	0.0028	0.7456	0.0016	0.0028	0.7733	0.0017	0.0028	0.8009	0.0018	0.0028	0.8286	0.0018	0.0028	0.8563	0.0028	0.00017			
30	0.7027	0.0015	0.0027	0.7297	0.0016	0.0027	0.7569	0.0016	0.0027	0.7839	0.0017	0.0027	0.8110	0.0017	0.0027	0.8386	0.0027	0.00019			
40	0.6879	0.0015	0.0026	0.7143	0.0015	0.0027	0.7409	0.0016	0.0027	0.7675	0.0016	0.0027	0.7942	0.0017	0.0027	0.8208	0.0027	0.00021			
50	0.6732	0.0015	0.0026	0.6992	0.0015	0.0026	0.7252	0.0016	0.0026	0.7512	0.0016	0.0026	0.7773	0.0016	0.0026	0.8034	0.0026	0.00023			
60	0.6588	0.0015	0.0026	0.6843	0.0015	0.0026	0.7098	0.0015	0.0026	0.7353	0.0016	0.0026	0.7609	0.0016	0.0026	0.7865	0.0026	0.00026			
70	0.6442	0.0015	0.0025	0.6692	0.0015	0.0025	0.6943	0.0015	0.0025	0.7193	0.0016	0.0025	0.7440	0.0016	0.0025	0.7686	0.0025	0.00029			
80	0.6297	0.0015	0.0025	0.6542	0.0015	0.0025	0.6789	0.0015	0.0025	0.7034	0.0015	0.0025	0.7280	0.0016	0.0025	0.7525	0.0025	0.00034			
90	0.6146	0.0015	0.0024	0.6388	0.0016	0.0024	0.6629	0.0016	0.0024	0.6870	0.0016	0.0024	0.7112	0.0017	0.0024	0.7353	0.0024	0.00039			
100	0.5991	0.0016	0.0024	0.6228	0.0016	0.0024	0.6465	0.0017	0.0024	0.6703	0.0017	0.0024	0.6939	0.0018	0.0024	0.7174	0.0024	0.00044			
110	0.5828	0.0016	0.0023	0.6060	0.0017	0.0023	0.6293	0.0017	0.0023	0.6526	0.0018	0.0023	0.6759	0.0019	0.0023	0.6991	0.0023	0.00051			
120	0.5653	0.0018	0.0023	0.5882	0.0018	0.0023	0.6111	0.0018	0.0023	0.6339	0.0019	0.0023	0.6569	0.0020	0.0023	0.6796	0.0023	0.00059			
130	0.5467	0.0019	0.0023	0.5692	0.0019	0.0023	0.5917	0.0019	0.0023	0.6142	0.0020	0.0023	0.6367	0.0022	0.0023	0.6590	0.0023	0.00068			
140	0.5262	0.0021	0.0022	0.5483	0.0021	0.0022	0.5704	0.0021	0.0022	0.5925	0.0022	0.0022	0.6147	0.0024	0.0022	0.6367	0.0022	0.00078			
150	0.5036	0.0023	0.0022	0.5253	0.0023	0.0022	0.5471	0.0023	0.0022	0.5689	0.0024	0.0022	0.5906	0.0026	0.0022	0.6118	0.0022	0.00090			
160	0.4788	0.0025	0.0022	0.5001	0.0025	0.0022	0.5216	0.0026	0.0021	0.5430	0.0026	0.0021	0.5644	0.0029	0.0021	0.5862	0.0021	0.00103			
170	0.4509	0.0028	0.0021	0.4720	0.0028	0.0021	0.4931	0.0029	0.0021	0.5141	0.0031	0.0021	0.5352	0.0033	0.0021	0.5569	0.0021	0.00118			
180	0.4197	0.0031	0.0021	0.4404	0.0031	0.0021	0.4611	0.0032	0.0021	0.4818	0.0034	0.0021	0.5026	0.0036	0.0021	0.5238	0.0021	0.00134			
190	0.3845	0.0035	0.0021	0.4049	0.0036	0.0021	0.4253	0.0036	0.0021	0.4457	0.0037	0.0021	0.4662	0.0038	0.0021	0.4868	0.0021	0.00153			
200	0.3449	0.0040	0.0020	0.3650	0.0040	0.0020	0.3851	0.0040	0.0020	0.4052	0.0041	0.0020	0.4254	0.0041	0.0020	0.4457	0.0020	0.00173			

Example. As an example of the use of the table No. 3 we will assume a case where it is desired to find the weight in pounds per cubic foot of air at a temperature of 83° dry- and 68° wet-bulb (or a depression of 15°) when the barometric pressure is 29.40 inches. From the table No. 3 we find that the weight of saturated air at 80° and 29.00 inch barometer is 0.07034 lb. per cu. ft. Also the decrement to be subtracted is 0.00015 lb. per degree of temperature above 80°. That is, the weight at 83° and 29.00 inches would be $0.07034 - (3 \times 0.00015) = 0.06989$ lb. per cu. ft. The increment is to be added per 0.1° increase in barometer above 29.00 inches is 0.00025, so that the weight of the saturated mixture at 83° and 29.40 inches will be $0.06989 + (4 \times 0.00025) = 0.07089$ lb. per cu. ft. From the last column in the table we find the increase in weight for each degree wet-bulb depression for a temperature of 83° to be $0.000034 + 0.3 (0.000039 - 0.000034) = 0.0000355$.

Then the weight of moist air at 83°, 15° wet-bulb depression, and 29.40 inch barometer will be:

$$0.07034 - 0.00045 + 0.001 + 0.00053 = 0.07142 \text{ lb. per cu. ft.}$$

Specific Heat of Air

The specific heat of air is the ratio of the heat required to raise the temperature of a given weight of air through one degree as compared to the heat required to raise the temperature of the same weight of water from 62 to 63 degrees Fahr., i. e., it is the B. t. u. required to raise one pound of air one degree Fahr.

The specific heat of air may be expressed as either of two factors, specific heat at constant pressure or at constant volume. It is the specific heat at constant pressure that is ordinarily referred to. The factors commonly used heretofore have been those determined by Renault—specific heat at constant pressure = 0.2375, and at constant volume = 0.1689. But recent investigation tends to show that the value 0.2375 is too low, and that it should be $C_p = 0.24112 + 0.000009t$ or for ordinary purposes approximately 0.2415.*

For the specific heats of various substances see the table on page 150.

Relation of Velocity to Pressure

The laws governing the flow of air are perhaps less understood than almost any other branch of engineering data. The flow of air under high pressures must necessarily be investigated thermodynamically and the formulae are more or less complicated. For ordinary fan work, however, where air is at low pressure but slight error is introduced if the same formulae are applied to the flow of air as are commonly used for the flow of water. The basic formula for such calculations is

$$V_s = \sqrt{2gh} \quad (10)$$

where V_s = velocity in ft. per second, or

$$V = 60 \sqrt{2gh} \quad (11)$$

where V = velocity in ft. per min.

g = acceleration due to gravity in feet per second

But we also have

$$h = h' \frac{d}{12W} \quad (12)$$

where h' = head expressed in in. of water

$d =$ density of water

W = weight of air in lbs. per cu. ft.

* "Rational Psychrometric Formulae," by Willis H. Carrier, Am. Soc. Mech. Engrs., December, 1911, also W. F. G. Swan, Phil. Trans. Royal Soc., Series A, Vol. 210, pp. 199-238.

Then at 70° F. and 29.92" barometer and with dry air

$$\frac{d}{12W} = \frac{62.31}{12 \times 0.07495} = 69.75$$

and we have

$$V = 60 \sqrt{2gh' \frac{d}{12W}} = 4005 \sqrt{h'} \quad (13)$$

Thus we see that the velocity at standard conditions stated for a pressure of one inch of water will be 4005 ft. per min., and for one ounce per square inch will be

$$4005 \sqrt{1.734} = 5273 \text{ ft. per min.} \quad (14)$$

The weight of dry or saturated air at other temperatures may be found from the tables No. 1 and No. 2, or for any special condition of temperature, barometer, or humidity from the table No. 3, the use of which has already been explained.

The most convenient formulae for determining the velocity or pressure of air under different conditions of temperature, barometer and humidity, when computing test results are the following:

$$V = 1096.5 \sqrt{\frac{p}{W}} \quad (15)$$

hence

$$p = \left(\frac{V}{1096.5} \right)^2 W \quad (16)$$

Where V = velocity in ft. per min.

p = pressure in in. of water.

W = weight of air in lbs. per cu. ft.

The quantity of air discharged through an orifice or nozzle due to a difference in pressure may be determined from

$$Q = 1096.5 C A \sqrt{\frac{p}{W}}$$

where. C = coefficient of discharge.

A = area of orifice in sq. ft.

p = pressure head in in. of water causing flow of air through orifice.

W = weight of air in lbs. per cu. ft.

For values of coefficient of discharge see "Coefficients of Discharge for Air Measurements", Pg. 177.

In case the pressure is expressed in ounces per square inch these formulae become:

$$V = 1444.5 \sqrt{\frac{p}{W}} \quad (17)$$

$$p = \left(\frac{V}{1444.5} \right)^2 W \quad (18)$$

and

$$Q = 1444.5 C A \sqrt{\frac{p}{W}}$$

The value to be used for W to be determined for each specific case, as already explained.

Example. As an example of the application of the above we will assume a case of a fan test made under the same atmospheric conditions as those assumed for the last example. That is, the air to be at 83° F. and 15" depression, with the barometer at 29.40 inches. What will be the velocity of this air at a pressure of 1.5 inches of water as measured by a pitot tube? As determined in the preceding example the weight of air under the above conditions will be 0.07142 lb. per cu. ft. Then from formula (15) we find the velocity to be

$$V = 1096.5 \sqrt{\frac{1.5}{0.07142}} = 5024 \text{ ft. per min.}$$

The above formulae are sufficiently accurate for low pressures such as are ordinarily used in fan work, but for high pressures such as are met in compressed air work, the error becomes excessive and it will be found necessary to use the following thermodynamic formulae. For the flow through an orifice from a higher to a lower pressure, where the absolute initial pressure is less than twice the absolute pressure of the discharge region,

$$V_s = 6552 \sqrt{T_1 \left[1 - \left(\frac{P_2}{P_1} \right)^{0.29} \right]} \quad (19)$$

where

V_s = velocity in ft. per min. at discharge.

P_1 = absolute initial press. in lb. per sq. in.

P_2 = absolute final press. in lb. per sq. in.

T_1 = absolute temp. degrees F. of entering air.

The discharge through an orifice into a region where the pressure is greater than half the initial pressure, expressed in cubic feet of free air per minute, may then be determined by the formula

$$Q = 218667 C A \frac{P_1}{\sqrt{T_1}} \sqrt{\left(\frac{P_2}{P_1} \right)^{1.42} - \left(\frac{P_2}{P_1} \right)^{1.71}} \quad (20)$$

where

Q = cu. ft. free air per min.

C = coefficient of discharge.

A = orifice area in sq. ft.

As already shown for dry air at 70° F. and 29.92 inch barometric pressure, the velocity due to a pressure of one inch of water is 4005 feet per minute and for a pressure of one ounce per square inch is 5273 feet per minute. Since the velocity varies as the square root of the pressure, we have

$$\frac{V}{V_0} = \sqrt{\frac{p}{p_0}} \text{ or } V = V_0 \sqrt{\frac{p}{p_0}} \quad (21)$$

Taking p_0 as unit pressure, and V_0 the velocity corresponding thereto, assuming dry air at 70° F. and 29.92 inch barometer, the above relation reduces to

$$V = 4005 \sqrt{p} \quad (22)$$

When the pressure is taken in inches

$$\text{or } V = 5273 \sqrt{p} \quad (23)$$

when the pressure is expressed in ounces.

The table No. 4 gives the velocity of dry air at standard conditions for various pressures expressed both in inches and ounces. The two tables, No. 5 and No. 6, give the corresponding velocities of dry air under standard barometric pressure of 29.92 inches for different pressures and temperatures. One table gives the velocity for even parts of an inch and the other for even parts of an ounce, with the corresponding pressure in the other unit.

Effect of Temperature and Barometric Pressure on Velocity

If considered at the same pressure the effect of changing the temperature of the air will change the corresponding velocity in direct proportion as the square root of the absolute temperatures. That is

$$V = V_0 \sqrt{\frac{460+t}{460+t_0}} \quad (24)$$

The tables No. 5 and No. 6 give the corresponding velocities for dry air at various pressures and temperatures, but the velocity for any other temperature may be determined from the above formula.

In connection with fan work we have the same relation—that is at constant pressure, the speed, capacity and horsepower of the fan varies as the square root of the ratio of the absolute temperatures. At constant velocity the weight and pressure of the air handled will vary inversely as the ratio of the absolute temperatures.

The velocity of air at constant pressure not only varies with any change in temperature, but also with every change in barometer. The velocity of the air varies inversely as the square root of the ratio of the barometric pressures. Then we will have

TABLE No. 4

CORRESPONDING PRESSURES AND VELOCITIES OF DRY AIR AT 70°
AND 29.92 INCHES BAROMETER

Inches of Water	Ounces per Sq. In.	Velocity Ft. per Min.	Inches of Water	Ounces per Sq. In.	Velocity Ft. per Min.
.05	.0289	896	4.77	2.750	8745
.10	.0577	1266	5.00	2.884	8943
.20	.1154	1791	5.20	3.000	9134
.25	.1443	2003	5.50	3.172	9392
.30	.1730	2193	6.00	3.460	9810
.40	.2308	2533	6.07	3.500	9864
.43	.2500	2637	6.50	3.749	10210
.50	.2884	2832	6.94	4.000	10545
.60	.3460	3102	7.00	4.037	10595
.70	.4037	3351	7.50	4.326	10968
.75	.4326	3468	7.80	4.500	11187
.80	.4614	3582	8.00	4.614	11328
.87	.5000	3729	8.67	5.000	11792
.90	.5190	3800	9.00	5.190	12015
1.00	.5768	4005	9.54	5.500	12367
1.25	.7209	4478	10.00	5.768	12665
1.30	.7500	4566	10.40	6.000	12915
1.50	.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

TABLE No. 5

CORRESPONDING VELOCITIES FOR DRY AIR AT VARIOUS PRESSURES AND TEMPERATURES
29.92 INCHES BAROMETER

Pressure		Temperature Degrees Fahr.									
Inches	Ounces	50°	60°	70°	80°	100°	150°	200°	300°	500°	550°
.1	.0577	1242	1255	1266	1278	1300	1358	1413	1516	1704	1830
.2	.1154	1757	1776	1791	1808	1841	1921	2000	2145	2411	2590
.25	.1443	1965	1986	2003	2022	2059	2149	2235	2399	2696	2895
.3	.1730	2151	2175	2193	2214	2254	2352	2447	2626	2952	3175
.4	.2308	2485	2512	2533	2557	2603	2717	2827	3033	3409	3680
.5	.2884	2778	2808	2832	2859	2911	3038	3160	3391	3812	4095
.6	.3460	3043	3076	3102	3131	3188	3327	3462	3715	4175	4490
.7	.4037	3287	3323	3351	3383	3445	3595	3740	4013	4510	4850
.75	.4326	3402	3439	3468	3501	3565	3720	3870	4153	4668	5020
.8	.4614	3524	3552	3582	3616	3682	3843	3997	4290	4821	5185
.9	.5190	3728	3768	3800	3836	3906	4070	4241	4550	5114	5500
1.0	.5768	3929	3971	4005	4043	4117	4286	4470	4796	5390	5795
1.25	.7209	4393	4440	4478	4520	4602	4804	4997	5362	6027	6470
1.50	.8650	4812	4864	4905	4952	5042	5262	5474	5802	6602	7100
1.75	1.0092	5197	5254	5298	5348	5446	5683	5912	6344	7131	7655
2.00	1.1535	5556	5616	5664	5718	5822	6076	6320	6783	7624	8195
2.25	1.2975	5892	5956	6007	6064	6174	6443	6704	7193	8055	8690
2.50	1.4418	6211	6278	6332	6392	6508	6792	7066	7582	8523	9150
2.75	1.5860	6514	6585	6641	6704	6827	7124	7412	7952	8938	9600
3.00	1.7300	6807	6879	6937	6994	7130	7440	7742	8307	9336	10000
3.25	1.8740	7087	7159	7216	7273	7414	7724	8026	8581	9636	10300
3.50	2.0185	7357	7429	7486	7543	7684	7994	8296	8851	9906	10570
3.75	2.1630	7627	7699	7756	7813	7954	8264	8566	9121	10176	10840
4.00	2.3070	7897	7969	8026	8083	8224	8534	8836	9391	10446	11110
4.25	2.4510	8167	8239	8296	8353	8494	8804	9106	9661	10716	11380
4.50	2.5950	8437	8509	8566	8623	8764	9074	9376	9931	10986	11650
4.75	2.7395	8707	8779	8836	8893	9034	9344	9646	10201	11256	11920

TABLE No. 6
CORRESPONDING VELOCITIES FOR DRY AIR AT VARIOUS PRESSURES AND TEMPERATURES
29.92 INCHES BAROMETER

Pressure		Temperature Degrees Fahr.									
		Inches	50°	60°	70°	80°	100°	150°	200°	300°	500°
Ounces											
.1	1.734	1635	1653	1667	1683	1714	1788	1860	1986	2244	2410
.2	3.468	2313	2338	2358	2380	2424	2530	2632	2824	3174	3405
.3	5.202	2833	2864	2888	2915	2969	3098	3223	3458	3887	4175
.4	6.936	3272	3307	3335	3367	3428	3578	3722	3994	4489	4850
.5	8.670	3658	3698	3729	3765	3833	4000	4162	4466	5019	5395
.6	1.0400	4007	4051	4085	4124	4199	4382	4559	4892	5498	5900
.7	1.2140	4329	4375	4412	4454	4535	4733	4924	5283	5938	6380
.8	1.3870	4626	4677	4716	4761	4848	5059	5263	5647	6347	6820
.9	1.5605	4907	4960	5002	5050	5142	5366	5582	5990	6733	7250
1.0	1.7340	5172	5229	5273	5323	5420	5656	5884	6314	7098	7625
1.1	1.9073	5426	5485	5531	5584	5685	5933	6172	6623	7444	8000
1.2	2.0808	5664	5725	5774	5828	5935	6194	6443	6914	7772	8350
1.3	2.2540	5896	5960	6011	6068	6179	6448	6708	7198	8090	8700
1.4	2.4275	6120	6186	6238	6297	6412	6692	6962	7470	8396	9020
1.5	2.6010	6335	6404	6457	6520	6638	6928	7207	7733	8692	9345
1.6	2.7742	6543	6614	6670	6734	6856	7155	7444	7987	8977	9650
1.8	3.1210	6942	7017	7076	7143	7274	7591	7877	8473	9524	10230
2.0	3.4680	7315	7395	7457	7528	7665	8000	8322	8830	10037	10750
2.2	3.8145	7672	7755	7820	7894	8038	8462	8727	9364	10525	11300
2.4	4.1615	8012	8099	8168	8245	8396	8782	9115	9781	10985	11800
2.6	4.5080	8338	8429	8500	8581	8737	9118	9456	10179	11440	12280
2.8	4.8550	8654	8748	8822	8906	9068	9464	9845	10564	11873	12750
3.0	5.2020	8960	9057	9134	9220	9388	9798	10193	10938	12293	13200

$$V = V_o \sqrt{\frac{b_o}{b}} \quad (25)$$

or where we wish to correct for both temperature and barometer

$$V = V_o \sqrt{\frac{460+t}{460+t_o}} \times \sqrt{\frac{b_o}{b}} \quad (26)$$

In the above formulae V represents the velocity of the air at temperature t degrees Fahr. and barometer b , while V_o is the corresponding velocity at temperature t_o and barometer b_o .

Relation of Altitude to the Properties of Air

The diagram, Fig 2, shows graphically the effect of different altitudes on the properties of air, and the two lines of relative air velocity and of air pressure and density are especially convenient in fan calculation.

As an illustration of the use of this diagram assume a case where a fan is to handle 150,000 A. P. M. at 0.5 inch static pressure at an altitude of 5000 feet. We must determine what sea level conditions correspond to these conditions at the given altitude and so be able to select a fan of the required capacity. From the chart we find the relative pressure at this altitude is 0.825, so that sea level pressure corresponding to 0.5 inch at 5,000 feet altitude will be $0.5 \div 0.825 = 0.6$ inch. The horsepower required to operate this fan will be 82.5 per cent. of the rated horsepower as given in the fan tables for the corresponding pressure of 0.6 inch static.

Any given amount of air as commonly specified will be increased in volume by this same ratio when we consider an altitude of say 5000 feet. Thus if we ordinarily require a definite quantity of air for a certain purpose this volume should be divided by 0.825 to determine the capacity required if the apparatus is to be installed at an altitude of 5000 feet, and a fan selected to handle this greater volume.

Effect of Temperature on the Volume of Air

Air at constant pressure changes its volume almost exactly in proportion to its absolute temperature ($460 + \text{temperature deg. Fahr.}$). The table No. 1 gives the relative volume of a given quantity of air at various temperatures as compared to the volume at 70° . For instance, the volume at 160° will be 1.17 times the volume at 70° . Expressed as a formula for use with other temperatures than those given in the table we will have, where Q is the volume at temperature t and Q_o the volume at t_o

$$Q = Q_o \left(\frac{460+t}{460+t_o} \right) \quad (27)$$

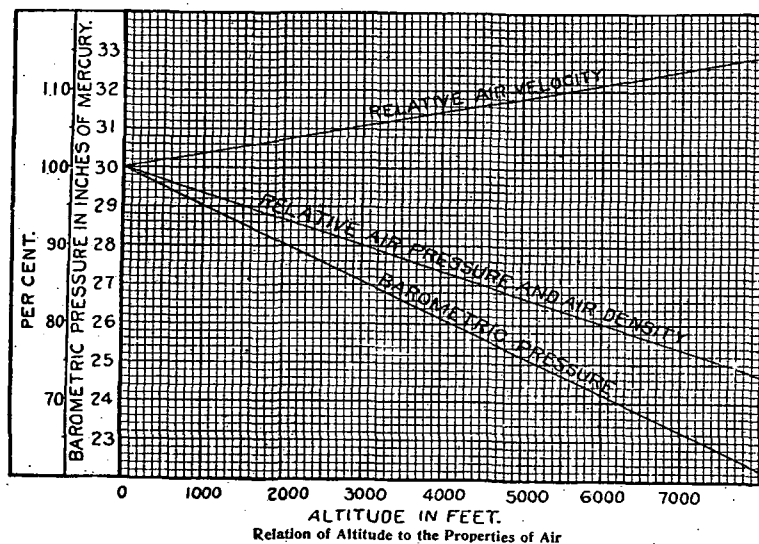
The effect of temperature on the various properties of air is shown graphically by the diagram, Fig. 3. As air at 70° is commonly used as a standard, these curves give the various relationships relative to air at 70° . Inasmuch as fan tables are usually based on air at 70° F., the upper curve of this diagram is especially applicable to fan calculations. Thus we see that if the air to be handled by a fan is at 140° , the velocity and fan speed would have to be increased to 106.5 per cent. of that given in the tables. Or if the velocity remains the same, the pressure and weight of air handled at 140° will be only 88 per cent. of the rated capacity.

Effect of Humidity on Velocity

It may be noted that the tables herein given, consider the various properties of dry air at the standard temperature and barometric pressure. But as a matter of fact, atmospheric air is not dry, so that a correction is necessary in order to reduce the actual observed velocity to the standard condition of dry air. This may be accomplished by means of the following relation, the cubic feet per pound of air being determined from the Psychrometric Charts, Figs. 6 and 7.

$$\frac{\text{Actual vel.}}{\text{Vel. Dry Air}} = \sqrt{\frac{\text{Cu. ft. per lb. air as observed}}{\text{Cu. ft. per lb. dry air}}} \quad (28)$$

FIG. 2



Coefficients of Discharge for Air Measurements

Various coefficients are used in the calculation of fan performance or in air measurements, and the following summary is given merely as a matter of convenience, but the factors should not be used without first having an intelligent understanding of their proper application. In case of special requirements it may be found necessary to modify the given coefficient accordingly.

Coefficient for sharp orifice in thin plate - - - - - 0.600
 Coefficient for orifice at end of pipe - - - - - $\frac{0.60}{\sqrt{1 - \left(\frac{A_2}{A_1}\right)^2}}$

Coef. for short pipe attached to end of larger pipe - - - - - $\frac{0.82}{\sqrt{1 - \left(\frac{A_2}{A_1}\right)^2}}$

Coefficient for short length of pipe (blowing from plenum chamber) - - - - - 0.82

Coefficient for short pipe on outlet of fan - - - - - 0.95

Coefficient for round pipe (pitot tube in center) - - - - - 0.91

Coefficient for converging nozzle (see curve).

The quantity of air to be measured may be calculated by means of the formula

$$Q = 1096.5 C A \sqrt{\frac{p}{W}}$$

where p = static pressure in inches causing flow of air.
 Q = cu. ft. air per min.
 C = coefficient of discharge.
 A = area of pipe in sq. ft.
 W = weight of air in lbs. per cu. ft.

For values of the weight of air in pounds per cubic foot for various atmospheric conditions see the table No. 3.

The coefficients given above are to be applied to velocity, capacity, or to the effective area of pipe or outlet. The proper coefficients to be applied to the pressure readings will be the square of the ones given above. Thus the coefficient for pressure in a round pipe varies from 0.81 to 0.82. These are to be applied to the pressure readings of the pitot tube when taken at the center of the pipe or duct. This coefficient for round pipes is based on test data, but should be decreased for pipes below 12 inches in diameter and increased by a small amount for pipes above 24 inches in diameter.

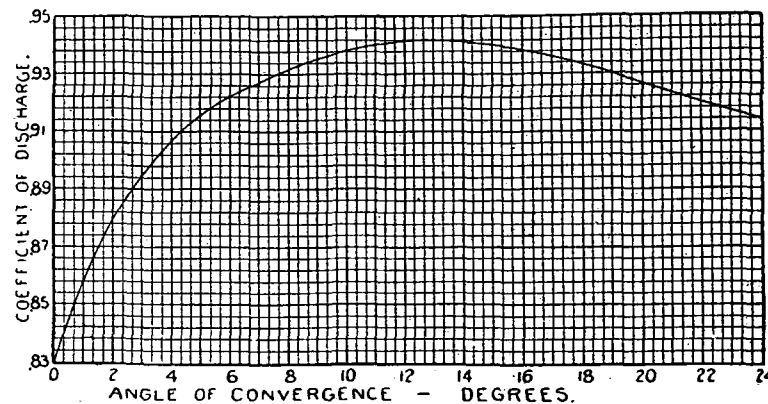
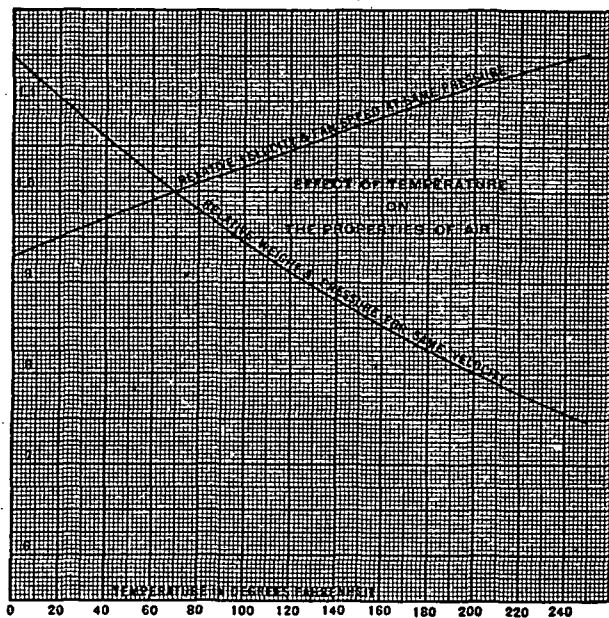


FIG. 3



HUMIDITY

Humidity is the moisture or water vapor mixed with the air in the atmosphere, and the weight of water vapor a given space will hold is dependent entirely on the temperature. The amount of vapor in any given space is independent of the presence of air, the only effect the air has being due to its temperature.

Absolute Humidity

Absolute humidity is the weight of a given volume of water vapor at a given temperature and percentage of saturation and is usually expressed as grains per cubic foot. The following tables give the weight of water vapor per cubic foot at different temperatures and percentages of saturation.

Relative Humidity

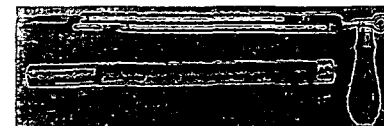
Relative humidity is the ratio of the weight of water vapor in a given space as compared to the weight which the same space is capable of containing when fully saturated at the same temperature. It is the ratio of the absolute humidity for the given condition to the absolute humidity at saturation. The quantity of moisture mixed with the air under different conditions of temperature and saturation is usually determined by means of some form of instrument in which a dry-bulb and a wet-bulb thermometer are used.

Dew-Point

The dew-point is the temperature at which saturation is obtained for a given weight of water vapor, or the point where any reduction in temperature would cause condensation of some of the water vapor. Any given amount of moisture must have some temperature at which saturation will occur and any further lowering of the temperature will cause condensation. This then will be its dew-point.

Dry-Bulb and Wet Bulb Thermometers

Usually the temperature of the air is determined by means of an ordinary or dry-bulb thermometer. The wet-bulb thermometer has the bulb covered with a piece of clean soft cloth and should be wet or dipped in water before taking a reading. Care should always be taken to keep the cloth free from dirt and to use pure clean water. This thermometer will give a depressed or lower reading than that of the dry-bulb thermometer in proportion to the evaporation from the wet surface of the cloth, and this depression is a measure of the amount of moisture in the air. This depressed reading corresponds to the temperature at which the air would normally saturate without any change in its heat contents. That is, the total heat in the air remains constant at a constant wet-bulb temperature. In order to obtain a true reading it is necessary that the thermometer be placed in a strong current of air.



The Sling Psychrometer

This instrument consists of a wet and a dry-bulb thermometer mounted on a strip of metal and provided with a handle which permits of the thermometer being rapidly whirled through the air. When being used the instrument should be whirled continuously until no further drop in the wet-bulb reading is noted. The difference between the readings of the two thermometers is the wet-bulb depression, and by referring to the tables or to the Psychrometric Charts, Figs. 5, 6 and 7, the corresponding psychrometric conditions may be determined. There are other forms of instruments, generally of some stationary type, used for taking humidity readings, but the instrument described is reasonably accurate and is the one used by the United States Weather Bureau.

Relation of Humidity to Heating

To understand more thoroughly the relation of humidity to heating, it is necessary to know that the temperature felt by the human body, or the sensible temperature, as it is called, corresponds to the temperature of the wet-bulb thermometer; hence, the drier the air the greater is the difference between the actual and sensible temperatures. Dry air heated much above the normal will still be chilly, slight drafts are very noticeable and colds are easily contracted.

The excessive evaporation from the skin lowers the temperature of the body very rapidly, and as a result higher temperatures are required than would be necessary for comfort if the proper amount of humidity were present. On the other hand, if the percentage of humidity is excessive, evaporation from the body is below normal, with the result that the body heat is not radiated as speedily as is necessary for comfort. In general, the higher the humidity maintained the lower the temperature required for the same degree of personal comfort.

Relation of Dry-Bulb, Wet-Bulb and Dew-Point Temperatures

The relation between the temperature as shown by the dry-bulb and wet-bulb thermometer, and the relation to the dew-point should be thoroughly understood by those expecting to become at all familiar with the subject of humidity.

Dew-point, as previously stated, is the temperature at which saturation is obtained for a given amount of water vapor. In other words, the air is at the dew-point when it contains all the moisture it will hold at a given temperature, and when it is impossible to get the air to absorb more water vapor without raising the temperature. When air has been reduced to the dew-point, both wet- and dry-bulb thermometer register exactly the same; for instance, air at 50° temperature and 100 per cent. saturation will contain 4.076 grains of moisture per cubic foot, under which condition the dry-bulb and wet-bulb thermometers

will both register 50°. If this air is heated, both thermometers will rise, but the wet-bulb temperature will rise more slowly and the relative humidity will be rapidly reduced: the dew-point remains constant at 50°, since any given number of grains of moisture per cubic foot has a fixed and definite dew-point or temperature of saturation.

If a cubic foot of air at a temperature of 87°, containing 4.076 grains per cubic foot with the wet-bulb temperature at 65°, is passed through a fine spray of recirculated water, it will absorb moisture; the dry-bulb temperature will immediately begin to fall, but the wet-bulb temperature will remain absolutely constant at 65° until the dry-bulb temperature has dropped to the wet-bulb temperature, namely, 65°. As the absorption takes place the dew-point will be gradually rising from 50° to 65°, when saturation is obtained. At ordinary temperatures the absorption of one grain of moisture per cu. ft. lowers the dry-bulb temperature approximately 8¼°.

Sensible, Latent and Total Heat

The total heat of air is composed of the sensible heat or heat due to the temperature of the air as indicated by the thermometer, and the latent heat or heat of vaporization of the moisture or vapor in the air. The total heat is a constant quantity for any certain wet-bulb temperature irrespective of any change in the dry-bulb temperature. This fact has been termed by W. H. Carrier* "One of the four fundamental psychrometric principles," and expressed as

"The true wet-bulb temperature of the air depends entirely on the total of the sensible and the latent heat in the air and is independent of their relative proportions. In other words, the wet-bulb temperature of the air is constant, providing the total heat of the air is constant."

Thus, if sufficient moisture is introduced into a certain quantity of air, the dry-bulb temperature of the air will be lowered until it is the same as the wet-bulb temperature. This is simply an exchange from sensible heat into latent heat required to vaporize the moisture, keeping the total heat the same. If a further lowering of the temperature takes place, the wet-bulb temperature will lower and the corresponding total heat will be less. If the air should be heated without the addition of more moisture, the dew-point temperature of the air would remain constant but the wet-bulb, as well as the dry-bulb temperature would increase, and the total heat of the air would increase a corresponding amount. The two Psychrometric Charts, Figs. 6 and 7, will be found especially convenient for determining the total heat of the air for any wet-bulb temperature.

Psychrometric Charts and Tables

Psychrometric Charts giving the properties of air as calculated by W. H. Carrier and published in his paper entitled "Rational Psychrometric Formulae," which was presented before the A. S. M. E. at the 1911 annual meeting, are shown in Figs. 6 and 7. These two charts are to be used when calculations are being made in terms of pounds of air, while the chart, Fig. 5, should be used for cubic feet of air. For most purposes of calculation it will be found preferable to use the pound as a unit.

The various curves shown on these charts will be found especially valuable in making air calculations. The grains of moisture per pound of dry air are read by passing directly from the dew-point, or intersection of the wet- and dry-bulb temperatures, to the scale on the left edge of the chart. The B. t. u. required to raise one pound of dry air one degree when saturated with moisture, as also the vapor pressure, may be determined by passing vertically from the dew-point to the proper curve, and then to the corresponding scale on the left edge of the chart. The total heat, in B. t. u., above zero degrees contained in one pound of dry air saturated with moisture may be found by passing vertically from the wet-bulb temperature to the total heat curve and then to the left edge of the chart. The volume of air in cubic feet per pound may be found by passing vertically from the dry-bulb temperature to either of the two volume curves and then to the left edge of the chart. One curve gives the volume of dry and the other of saturated air.

* "Rational Psychrometric Formulae." Am. Soc. Mech. Engrs., Dec., 1911.

Example. As an example of the use of this chart we will assume air at 75° dry-bulb temperature and 60 per cent. relative humidity. From the chart we find that the wet-bulb temperature will be 65.25°, the dew-point 60°, the grains of moisture per pound of dry air 77; the heat required to raise one pound of dry air saturated at 60° through one degree is 0.24664 B. t. u.; and the vapor pressure of air saturated at 60° is 0.523 inches of mercury. Passing vertically from the wet-bulb temperature of 65.25° to the total heat curve and thence to the scale on the left, we find the total heat above zero in one pound of dry air when saturated at 65.25° to be 29.75 B. t. u. This, then, is also the measure of the heat in a pound of air at 75° and 60 per cent. relative humidity, since the wet-bulb temperature is the same.

The cubic feet per pound of air may be found by passing vertically from the dry-bulb temperature to either of the two volume curves, depending on whether the volume of dry or of saturated air is desired. To determine the volume of one pound of partly saturated air as here assumed, we will have from the chart;

Cu. ft. per lb. at 75° sat. = 13.88

Cu. ft. per lb. at 75° dry = 13.48

.40 = Moisture

.60 = Rel. humidity

.24

13.48

Cu. ft. per lb. at 75° and 60% = 13.72

The Psychrometric Chart, Fig. 5, and the following tables are taken from the catalog of the Carrier Air Conditioning Company of America. They show the grains of moisture per cubic foot of saturated air at various temperatures, as well as the relative humidity, the dew-point temperature and the grains of moisture per cubic foot of air for different temperatures as determined by the wet and dry-bulb of the sling psychrometer.

As an example of the use of the chart, Fig. 5, we will assume a case where the dry-bulb temperature is 80° and the wet-bulb thermometer reads 70°, or a 10° depression. From the intersection of the corresponding lines through these two temperatures we find the relative humidity to be 62 per cent. Passing horizontally to the left from this point of intersection to the wet-bulb temperature line (called the saturation curve) we find the dew-point temperature to be 64.5°. If the temperature of the air should be reduced, both the dry and wet-bulb readings will be lowered until they both read 64.5°, when the air will be saturated. The grains of moisture contained in each cubic foot of this air will be found by continuing to the left on the horizontal line through the 64.5° dew-point to the left edge of the chart, where we have a reading of 6.65 grains. If the temperature of the air be further reduced, part of the moisture content will be condensed, the dew-point or saturation temperature will be lowered, and the grains of moisture per cubic foot will be correspondingly less.

In case more accurate readings are desired than can be determined from a chart on as small a scale as Fig. 5, the psychrometric tables may be used.

FIG. 5

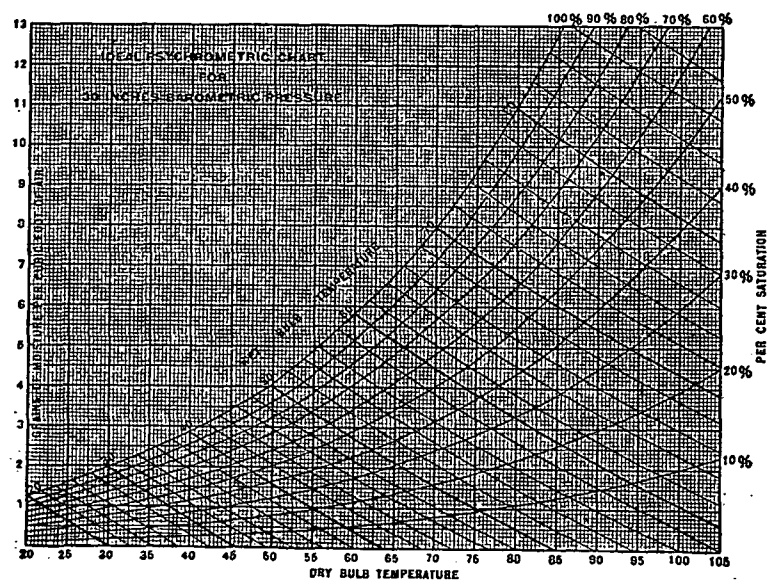
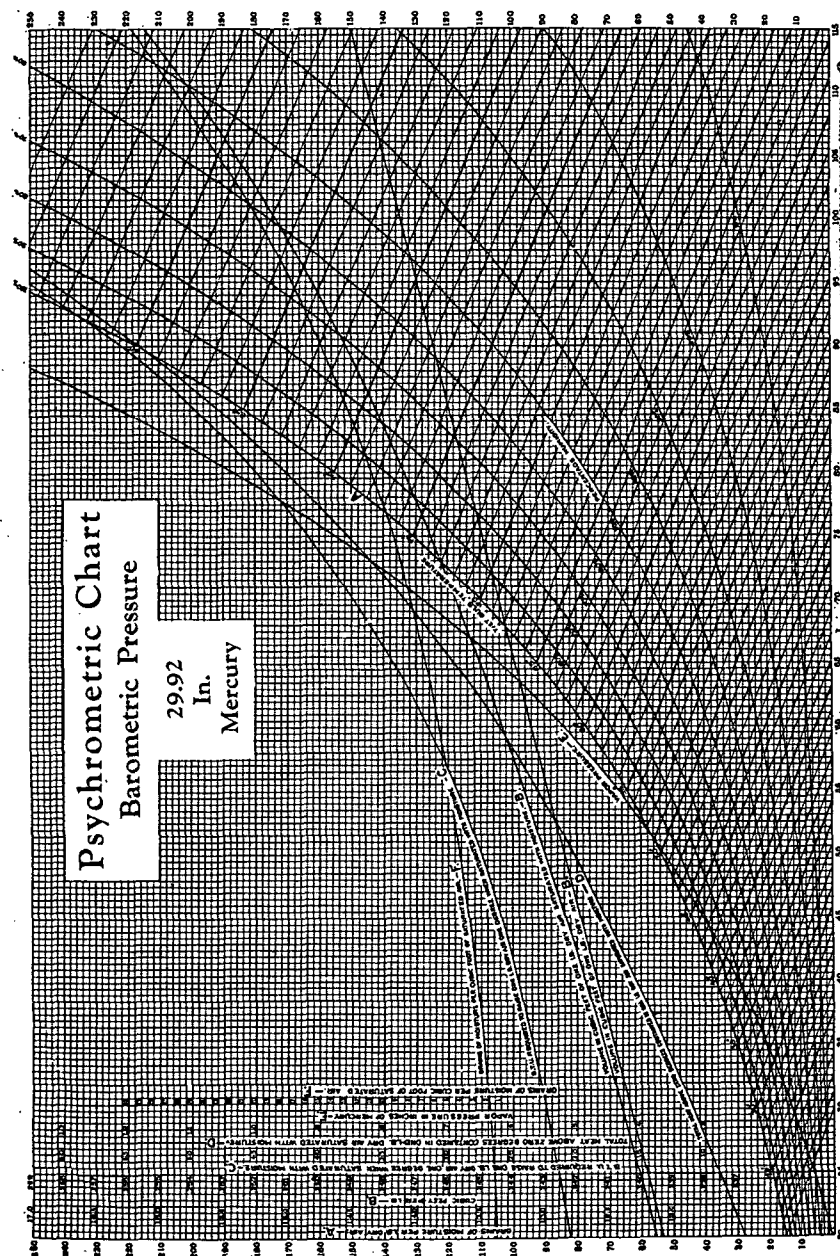
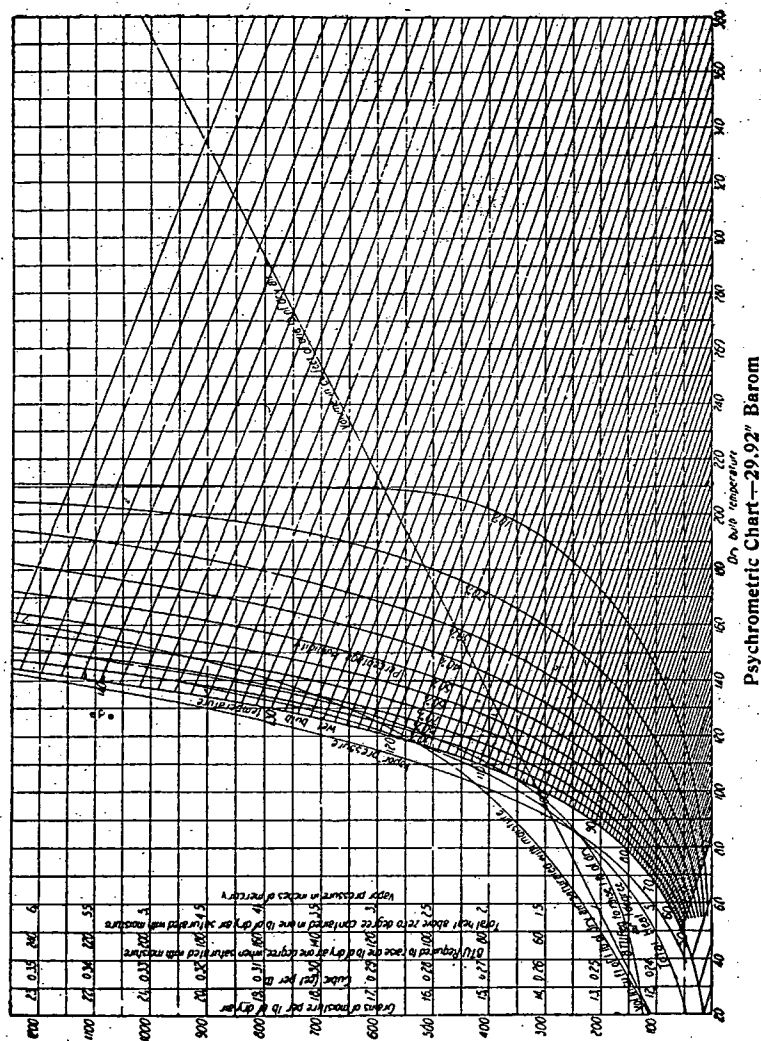


FIG. 6





RELATIVE HUMIDITY, DEW-POINTS AND GRAINS OF MOISTURE PER CUBIC FOOT

Barometric Pressure—30 Inches

Degrees Wet-Bulb Depression

Dry-Bulb Temp.	Grains per Cu. Ft. at Saturation	1°			2°			3°			4°		
		% Rel. Hum.	Dew- Point	Grs. per Cu. Ft.	% Rel. Hum.	Dew- Point	Grs. per Cu. Ft.	% Rel. Hum.	Dew- Point	Grs. per Cu. Ft.	% Rel. Hum.	Dew- Point	Grs. per Cu. Ft.
0	.48	67	-7	.32	33	-20	.16						
2	.53	70	-5	.37	39	-15	.21	9	-40	.05			
4	.58	72	-2	.42	44	-11	.26	17	-28	.10			
6	.64	74	0	.47	49	-8	.32	23	-21	.15			
8	.70	76	3	.54	53	-5	.37	29	-15	.20	6	-42	.04
10	.78	78	5	.61	56	-2	.44	34	-10	.26	13	-27	.11
12	.86	80	7	.69	59	2	.51	39	-6	.33	19	-19	.16
14	.94	81	10	.76	62	5	.58	44	-2	.41	26	-12	.25
16	1.03	82	12	.85	65	7	.65	48	+1	.50	31	-7	.32
18	1.13	84	14	.95	68	10	.72	52	5	.59	36	-2	.41
20	1.24	85	16	1.10	70	12	.86	55	8	.68	40	+2	.49
22	1.36	86	19	1.17	71	15	.96	58	11	.79	44	5	.60
24	1.48	87	21	1.30	73	17	1.10	60	13	.89	47	9	.70
26	1.62	87	23	1.41	75	20	1.22	63	16	1.02	51	12	.83
28	1.77	88	25	1.56	76	22	1.37	65	19	1.15	54	15	.96
30	1.94	89	27	1.72	78	25	1.50	67	21	1.30	56	18	1.08
32	2.11	89	30	1.88	79	27	1.67	69	24	1.46	59	21	1.25
34	2.28	90	32	2.05	81	29	1.85	71	26	1.62	62	23	1.41
36	2.46	91	34	2.24	82	31	2.02	73	29	1.79	64	26	1.57
38	2.65	91	36	2.41	83	33	2.20	75	31	1.98	66	28	1.74
40	2.85	92	38	2.62	83	35	2.36	75	33	2.14	68	30	1.94
42	3.08	92	40	2.82	85	38	2.61	77	35	2.36	69	33	2.12
44	3.29	93	42	3.06	85	40	2.80	78	37	2.57	71	35	2.34
46	3.54	93	44	3.29	86	42	3.04	79	40	2.80	72	37	2.54
48	3.80	93	46	3.53	86	44	3.27	79	42	3.00	73	40	2.77
50	4.08	93	48	3.79	87	46	3.55	80	44	3.26	74	42	3.02
52	4.37	94	50	4.11	87	48	3.80	81	46	3.54	75	44	3.28
54	4.69	94	52	4.40	88	50	4.13	82	48	3.84	76	46	3.56
56	5.02	94	54	4.71	88	53	4.41	82	51	4.11	76	49	3.81
58	5.37	94	56	5.05	88	55	4.73	83	53	4.46	77	51	4.14
59	5.56	94	57	5.22	89	56	4.95	83	54	4.61	78	52	4.33
60	5.75	94	58	5.40	89	57	5.11	83	55	4.77	78	53	4.48
61	5.94	94	59	5.58	89	58	5.29	84	56	4.99	78	54	4.64
62	6.14	94	60	5.77	89	59	5.46	84	57	5.16	79	55	4.85
63	6.35	95	61	6.03	89	60	5.65	84	58	5.23	79	56	5.01
64	6.56	95	62	6.24	90	61	5.91	84	59	5.51	79	57	5.19
65	6.78	95	63	6.44	90	62	6.10	85	60	5.77	80	59	5.43
66	7.01	95	64	6.66	90	63	6.31	85	61	5.96	80	60	5.61
67	7.24	95	65	6.88	90	64	6.52	85	62	6.16	80	61	5.79
68	7.48	95	67	7.10	90	65	6.73	85	63	6.36	80	62	5.98
69	7.73	95	68	7.34	90	66	6.95	85	64	6.57	81	63	6.26
70	7.98	95	69	7.58	90	67	7.18	86	65	6.86	81	64	6.46
71	8.24	95	70	7.83	90	68	7.42	86	67	7.09	81	65	6.67
72	8.51	95	71	8.08	91	69	7.74	86	68	7.31	82	66	6.97
73	8.78	95	72	8.34	91	70	7.99	86	69	7.55	82	67	7.20
74	9.07	95	73	8.61	91	71	8.25	86	70	7.80	82	68	7.43
75	9.36	96	74	8.89	91	72	8.51	86	71	8.05	82	69	7.67
76	9.66	96	75	9.27	91	73	8.79	87	72	8.40	82	70	7.92

RELATIVE HUMIDITY, DEW-POINTS AND GRAINS OF MOISTURE PER CUBIC FOOT—Barometric Pressure, 30 Inches

Degrees Wet-Bulb Depression										
Dry-Bulb Temp.	Grains per Cu. Ft. at Saturation	1°			2°			3°		
		% Rel. Hum.	Dew-Point	Grs. per Cu. Ft.	% Rel. Hum.	Dew-Point	Grs. per Cu. Ft.	% Rel. Hum.	Dew-Point	Grs. per Cu. Ft.
77	9.96	96	76	9.56	91	74	9.02	87	73	8.67
78	10.28	96	77	9.87	91	75	9.35	87	74	8.94
79	10.60	96	78	10.18	91	76	9.65	87	75	9.21
80	10.93	96	79	10.50	91	77	9.95	87	76	9.51
81	11.23	96	80	10.82	92	78	10.37	88	77	9.92
82	11.63	96	81	11.16	92	79	10.70	88	78	10.23
83	11.99	96	82	11.51	92	80	11.03	88	79	10.55
84	12.36	96	83	11.86	92	81	11.37	88	80	10.87
85	12.74	96	84	12.22	92	82	11.72	88	81	11.21
86	13.13	96	85	12.60	92	83	12.08	88	82	11.55
87	13.53	96	86	12.99	92	84	12.44	88	83	11.90
88	13.94	96	87	13.38	92	85	12.82	88	84	12.26
89	14.36	96	88	13.99	92	86	13.21	88	85	12.64
90	14.79	96	89	14.20	92	87	13.61	89	86	13.16
92	15.69	96	91	15.06	92	89	14.44	89	88	13.96
94	16.63	96	93	15.97	93	92	15.47	89	90	14.81
96	17.63	96	95	16.92	93	94	16.39	89	92	15.69
98	18.67	96	97	17.92	93	96	17.36	89	94	16.62
100	19.77	96	99	18.98	93	98	18.38	89	96	17.59
104	22.13	97	103	21.46	93	102	20.58	90	100	19.91
108	24.72	97	107	23.98	93	106	22.99	90	104	22.25
112	27.88	97	111	27.02	94	110	26.19	90	109	25.07
116	30.10	97	115	29.20	94	114	28.29	91	113	27.39
120	34.80	97	119	33.76	94	118	32.71	91	117	31.67
Dry-Bulb Temp.	Grains per Cu. Ft. at Saturation	5°			6°			7°		
		% Rel. Hum.	Dew-Point	Grs. per Cu. Ft.	% Rel. Hum.	Dew-Point	Grs. per Cu. Ft.	% Rel. Hum.	Dew-Point	Grs. per Cu. Ft.
20	1.24	26	-7	.32	12	-21	.15			
22	1.36	31	-2	.42	17	-12	.23	4	-36	.05
24	1.48	35	+2	.52	22	-6	.33	10	-20	.15
26	1.62	39	+7	.63	27	-1	.44	16	-11	.26
28	1.77	43	10	.76	32	+4	.52	21	-4	.37
30	1.94	46	14	.89	36	8	.70	26	+2	.50
32	2.11	49	17	1.03	39	12	.82	30	7	.63
34	2.28	52	20	1.19	43	16	.98	34	11	.78
36	2.46	55	23	1.35	46	19	1.13	38	15	.93
38	2.65	58	25	1.54	50	22	1.32	42	18	1.11
40	2.85	60	28	1.71	52	25	1.48	45	21	1.28
42	3.06	62	30	1.90	55	27	1.69	47	24	1.44
44	3.29	63	32	2.08	56	30	1.85	49	27	1.61
46	3.54	65	35	2.30	58	32	2.05	52	29	1.84
48	3.80	66	37	2.51	60	35	2.28	54	32	2.05
50	4.08	67	40	2.73	61	37	2.49	55	34	2.24

RELATIVE HUMIDITY, DEW-POINTS AND GRAINS OF MOISTURE PER CUBIC FOOT

Barometric Pressure—30 Inches

Degrees Wet-Bulb Depression										
Dry-Bulb Temp.	% Rel. Hum.	5°			6°			7°		
		Dew-Point	Grs. per Cu. Ft.	% Rel. Hum.	Dew-Point	Grs. per Cu. Ft.	% Rel. Hum.	Dew-Point	Grs. per Cu. Ft.	% Rel. Hum.
52	69	42	3.02	63	40	2.75	57	37	2.49	51
54	70	44	3.28	64	42	3.00	59	40	2.77	53
56	71	47	3.61	65	44	3.26	60	42	3.01	55
58	72	49	3.87	66	47	3.55	61	45	3.28	56
59	72	50	4.00	67	48	3.72	62	46	3.44	57
60	73	51	4.19	68	49	3.91	63	47	3.62	58
61	73	52	4.34	68	50	4.04	63	48	3.74	58
62	74	53	4.54	69	52	4.24	64	50	3.93	59
63	74	55	4.71	69	53	4.38	64	51	4.07	60
64	74	56	4.86	70	54	4.59	65	52	4.27	60
65	75	57	5.09	70	55	4.75	66	53	4.48	61
66	75	58	5.26	71	56	4.98	66	54	4.63	61
67	75	59	5.43	71	57	5.14	66	55	4.78	62
68	76	60	5.69	71	58	5.31	67	57	5.01	62
69	76	61	5.87	72	59	5.56	67	58	5.18	63
70	77	62	6.15	72	61	5.75	68	59	5.43	64
71	77	63	6.35	72	62	5.93	68	60	5.60	64
72	77	64	6.55	73	63	6.21	69	61	5.87	65
73	78	66	6.85	73	64	6.41	69	62	6.06	65
74	78	67	7.07	74	65	6.71	69	63	6.26	65
75	78	68	7.30	74	66	6.92	70	64	6.59	66
76	78	69	7.53	74	67	7.14	70	66	6.76	66
77	79	70	7.87	74	68	7.37	71	67	7.07	67
78	79	71	8.12	75	69	7.71	71	68	7.30	67
79	79	72	8.38	75	70	7.95	71	69	7.53	68
80	79	73	8.64	75	72	8.20	72	70	7.87	68
81	80	74	9.02	76	73	8.57	72	71	8.12	69
82	80	75	9.30	76	74	8.84	72	72	8.37	69
83	80	76	9.59	76	75	9.11	73	73	8.75	69
84	80	77	9.89	76	76	9.39	73	74	9.02	69
85	81	78	10.32	77	77	9.81	73	75	9.30	70
86	81	79	10.63	77	78	10.11	73	76	9.58	70
87	81	80	10.96	77	79	10.42	74	78	10.01	70
88	81	81	11.29	77	80	10.73	74	79	10.31	70
89	81	82	11.63	78	81	11.20	74	80	10.63	71
90	81	83	11.98	78	82	11.54	74	81	10.94	71
92	82	86	12.87	78	84	12.24	75	83	11.77	72
94	82	88	13.64	79	86	13.14	75	85	12.48	72
96	82	90	14.45	79	88	13.93	76	87	13.40	73
98	83	92	15.50	79	90	14.75	76	89	14.19	73
100	83	94	16.41	80	93	15.81	77	91	15.22	73
104	83	98	18.36	80	97	17.70	77	95	17.04	74
108	84	102	20.77	81	101	20.02	78	100	19.28	75
112	84	106	23.40	81	105	22.57	79	104	21.60	76
116	85	110	26.31	82	109	25.40	79	108	24.50	76
120	85	114	29.58	82	113	28.88	80	112	27.84	77

RELATIVE HUMIDITY, DEW-POINTS AND GRAINS OF MOISTURE PER CUBIC FOOT

Barometric Pressure—30 Inches

Degrees Wet-Bulb Depression

Dry-Bulb Temp.	9°			10°			11°			12°		
	% Rel. Hum.	Dew- Point	Grs. per Cu. Ft.	% Rel. Hum.	Dew- Point	Grs. per Cu. Ft.	% Rel. Hum.	Dew- Point	Grs. per Cu. Ft.	% Rel. Hum.	Dew- Point	Grs. per Cu. Ft.
40	29	13	0.83	22	7	0.63	15	-1	0.43	7	-14	0.20
42	33	17	1.01	26	12	0.80	19	6	0.58	12	-3	0.37
44	36	20	1.19	30	16	0.99	23	11	0.76	16	4	0.53
46	39	23	1.38	32	20	1.13	26	15	0.92	20	10	0.71
48	41	26	1.56	35	23	1.33	29	19	1.11	23	14	0.88
50	43	29	1.75	38	26	1.55	32	22	1.30	27	18	1.10
52	46	32	2.01	40	29	1.75	35	26	1.53	29	22	1.27
54	48	34	2.25	42	32	1.97	37	29	1.73	32	25	1.49
56	50	37	2.51	44	34	2.21	39	32	1.96	34	29	1.71
58	51	40	2.74	46	37	2.47	41	35	2.20	37	32	1.99
60	53	43	3.04	48	40	2.76	43	38	2.47	39	35	2.25
62	54	45	3.32	50	43	3.07	45	40	2.76	41	38	2.52
64	56	48	3.68	51	46	3.35	47	43	3.09	43	41	2.82
66	57	50	3.99	53	48	3.71	48	46	3.36	44	44	3.08
67	58	52	4.20	53	49	3.84	49	47	3.55	45	45	3.19
68	58	53	4.34	54	51	4.04	50	49	3.74	46	46	3.44
69	59	54	4.56	55	52	4.25	51	50	3.94	47	48	3.63
70	59	55	4.71	55	53	4.39	51	51	4.07	48	49	3.83
71	60	56	4.94	56	54	4.62	52	52	4.29	48	50	3.96
72	61	58	5.19	57	56	4.86	53	54	4.51	49	52	4.17
73	61	59	5.36	57	57	5.01	53	55	4.65	50	53	4.39
74	61	60	5.53	58	58	5.26	54	56	4.90	50	54	4.53
75	62	61	5.80	58	59	5.43	54	57	5.05	51	55	4.77
76	62	62	5.99	59	60	5.70	55	59	5.31	51	57	4.92
77	63	63	6.28	59	62	5.88	56	60	5.58	52	58	5.18
78	63	64	6.47	60	63	6.17	56	61	5.76	53	59	5.45
79	64	66	6.79	60	64	6.36	57	62	6.04	53	60	5.62
80	64	67	7.00	61	65	6.67	57	63	6.23	54	62	5.90
81	65	68	7.33	61	66	6.88	58	65	6.54	55	63	6.20
82	65	69	7.56	61	67	7.09	58	66	6.74	55	64	6.39
83	66	70	7.91	62	69	7.43	59	67	7.07	56	65	6.71
84	66	71	8.16	62	70	7.66	59	68	7.29	56	66	6.92
85	66	72	8.41	63	71	8.02	60	69	7.64	57	68	7.26
86	66	73	8.67	63	72	8.27	60	70	7.88	57	69	7.48
87	67	75	9.06	64	73	8.66	61	72	8.25	57	70	7.71
88	67	76	9.34	64	74	8.92	61	73	8.50	57	71	7.94
89	68	77	9.76	65	75	9.33	61	74	8.76	58	72	8.33
90	68	78	10.06	65	76	9.61	61	75	9.09	58	73	8.58
92	68	80	10.67	65	79	10.20	62	77	9.73	59	76	9.26
94	69	82	11.48	66	81	10.98	63	79	10.48	60	78	9.98
96	69	84	12.16	66	83	11.63	63	82	11.11	61	80	10.75
98	70	87	13.07	67	85	12.51	64	84	11.95	61	82	11.39
100	70	89	13.84	68	87	13.44	65	86	12.85	62	85	12.26
104	71	93	15.71	69	92	15.27	66	90	14.60	63	89	13.94
108	72	97	17.80	70	96	17.30	67	95	16.56	64	93	15.82
112	73	101	20.34	70	100	19.50	68	99	18.94	65	98	18.11
116	74	105	22.99	71	104	22.05	69	103	21.45	66	102	20.55
120	74	110	25.71	72	108	25.01	69	107	23.95	67	106	23.24

RELATIVE HUMIDITY, DEW-POINTS AND GRAINS OF MOISTURE PER CUBIC FOOT

Barometric Pressure—30 Inches

Degrees Wet-Bulb Depression

Dry-Bulb Temp.	13°			14°			15°			16°		
	% Rel. Hum.	Dew- Point	Grs. per Cu. Ft.	% Rel. Hum.	Dew- Point	Grs. per Cu. Ft.	% Rel. Hum.	Dew- Point	Grs. per Cu. Ft.	% Rel. Hum.	Dew- Point	Grs. per Cu. Ft.
50	21	13	0.86	16	8	0.65	10	0	0.41	5	-13	0.20
52	24	18	1.05	19	13	0.83	14	7	0.61	9	-2	0.39
54	27	22	1.27	22	18	1.03	17	12	0.80	12	6	0.56
56	30	25	1.51	25	22	1.25	20	17	1.00	16	12	0.80
58	32	29	1.72	27	25	1.45	23	21	1.24	18	17	0.97
59	33	30	1.83	29	27	1.61	24	23	1.33	20	19	1.11
60	34	32	1.95	30	29	1.72	26	25	1.50	21	21	1.21
61	35	33	2.08	31	30	1.84	27	27	1.60	22	23	1.31
62	36	35	2.21	32	32	1.97	28	29	1.72	24	25	1.47
63	37	36	2.34	33	34	2.17	29	30	1.84	25	27	1.59
64	38	38	2.49	34	35	2.23	30	32	1.97	26	29	1.71
65	39	40	2.65	35	37	2.37	31	34	2.10	27	31	1.83
66	40	41	2.80	36	38	2.52	32	35	2.24	29	32	2.03
67	41	43	2.97	37	40	2.68	33	37	2.39	30	34	2.17
68	42	44	3.14	38	42	2.84	34	39	2.54	31	36	2.32
69	43	45	3.32	39	43	3.01	35	40	2.70	32	37	2.47
70	44	47	3.51	40	44	3.19	36	42	2.87	33	39	2.63
71	45	48	3.71	41	46	3.38	37	43	3.05	33	41	2.72
72	45	50	3.83	42	47	3.57	38	45	3.23	34	42	2.89
73	46	51	4.04	42	49	3.69	39	46	3.43	35	44	3.07
74	47	52	4.26	43	50	3.90	39	48	3.54	36	45	3.26
75	47	54	4.40	44	51	4.12	40	49	3.74	37	47	3.46
76	48	55	4.64	44	53	4.25	41	51	3.96	38	48	3.67
77	48	56	4.78	45	54	4.48	42	52	4.18	39	50	3.89
78	49	57	5.04	46	55	4.73	43	53	4.42	39	51	4.01
79	50	59	5.30	46	57	4.88	43	55	4.56	40	53	4.24
80	50	60	5.47	47	58	5.14	44	56	4.81	41	54	4.48
81	51	61	5.75	48	59	5.41	45	57	5.07	42	55	4.74
82	51	62	5.93	48	60	5.58	45	59	5.23	42	57	4.88
83	52	64	6.23	49	62	5.87	46	60	5.52	43	58	5.01
84	52	65	6.43	49	63	6.06	46	61	5.68	43	59	5.31
85	53	66	6.75	50	64	6.37	47	62	5.99	44	61	5.60
86	53	67	6.96	50	65	6.56	47	64	6.17	44	62	5.78
87	54	68	7.17	51	67	6.90	48	65	6.49	46	63	6.22
88	54	69	7.53	51	68	7.11	48	66	6.69	46	64	6.41
89	55	71	7.90	52	69	7.47	49	67	7.04	47	66	6.75
90	55	72	8.13	52	70	7.69	49	69	7.25	47	67	6.95
92	56	74	8.79	53	73	8.32	50	71	7.84	48	69	7.53
94	57	76	9.48	54	75	8.98	51	73	8.48	49	72	8.15
96	58	79	10.22	55	77	9.69	52	76	9.17	50	74	8.81
98	58	81	10.83	56	79	10.46	53	78	9.90	50	76	9.34
100	59	83	11.66	56	82	11.07	54	80	10.67	51	79	10.08
104	60	88	13.28	58	86	12.83	55	85	12.17	53	83	11.73
108	62	92	15.33	59	91	14.59	57	89	14.09	54	88	13.35
112	63	96	17.55	60	95	16.72	58	94	16.16	55	92	15.39
116	64	101	19.95	61	99	19.05	59	98	18.45	57	97	17.85
120	65	105	22.40	62	104	21.46	60	102	20.75	58	101	20.07

RELATIVE HUMIDITY, DEW-POINTS AND GRAINS OF MOISTURE PER CUBIC FOOT

Barometric Pressure—30 Inches

Degrees Wet-Bulb Depression

Dry-Bulb Temp.	17°			18°			19°			20°		
	% Rel. Hum.	Dew- Point	Grs. per Cu. Ft.	% Rel. Hum.	Dew- Point	Grs. per Cu. Ft.	% Rel. Hum.	Dew- Point	Grs. per Cu. Ft.	% Rel. Hum.	Dew- Point	Grs. per Cu. Ft.
52	4	-17	0.18									
54	8	-4	0.38	3	-20	0.14						
56	11	5	0.55	7	-5	0.35	2	-25	0.10			
58	14	11	0.75	10	4	0.54	6	-6	0.32	1	-30	0.05
59	16	14	0.89	11	8	0.61	7	0	0.42	3	-20	0.14
60	17	17	0.98	13	11	0.75	9	4	0.52	5	-8	0.29
61	18	19	1.07	14	14	0.83	10	8	0.63	6	-1	0.39
62	20	21	1.23	16	16	0.98	12	11	0.74	8	3	0.49
63	21	23	1.33	17	19	1.08	14	14	0.86	10	7	0.60
64	22	25	1.44	18	21	1.18	15	17	0.98	11	11	0.72
65	24	27	1.63	20	24	1.36	16	19	1.09	13	14	0.86
66	25	29	1.75	21	26	1.47	17	22	1.19	14	17	0.98
67	26	31	1.88	22	28	1.59	18	24	1.35	15	19	1.09
68	27	33	2.00	23	29	1.72	20	26	1.50	16	22	1.20
69	28	34	2.16	24	31	1.85	21	28	1.63	17	24	1.36
70	29	36	2.31	25	33	2.00	22	30	1.76	19	26	1.52
71	30	38	2.47	27	35	2.23	23	32	1.85	20	28	1.66
72	31	40	2.64	28	37	2.38	24	33	2.04	21	30	1.79
73	32	41	2.81	29	38	2.55	25	35	2.20	22	32	1.94
74	33	43	2.99	29	40	2.63	26	37	2.36	23	34	2.09
75	34	44	3.18	30	42	2.81	27	39	2.53	24	36	2.25
76	34	46	3.28	31	43	2.99	28	41	2.70	25	38	2.41
77	35	48	3.49	32	45	3.19	29	42	2.89	26	39	2.59
78	36	49	3.70	33	46	3.39	30	44	3.08	27	41	2.78
79	37	50	3.92	34	48	3.60	31	46	3.29	28	43	2.97
80	38	52	4.16	35	50	3.83	32	47	3.50	29	44	3.17
81	39	53	4.40	36	51	4.06	33	49	3.72	30	46	3.38
82	39	55	4.53	36	52	4.19	33	50	3.84	30	48	3.49
83	40	56	4.65	37	54	4.44	34	52	4.08	31	49	3.72
84	40	57	4.94	37	55	4.57	35	53	4.33	32	51	3.95
85	41	59	5.22	38	57	4.84	36	54	4.59	33	52	4.20
86	42	60	5.52	39	58	5.12	36	56	4.73	33	54	4.33
87	43	61	5.82	40	59	5.41	37	57	5.00	34	55	4.60
88	43	62	5.99	40	61	5.58	37	59	5.16	35	57	4.88
89	44	64	6.32	41	62	5.89	38	60	5.46	36	58	5.17
90	44	65	6.51	41	63	6.06	39	61	5.77	36	59	5.33
92	45	68	7.06	42	66	6.59	40	64	6.28	37	62	5.81
94	46	70	7.65	43	68	7.15	41	67	6.82	38	65	6.32
96	47	72	8.28	44	71	7.76	42	69	7.40	39	67	6.87
98	48	75	8.96	45	73	8.40	43	72	8.03	40	70	7.47
100	49	77	9.69	46	76	9.09	44	74	8.70	41	72	8.10
104	50	82	11.06	48	80	10.62	46	79	10.18	43	77	9.51
108	52	86	12.85	49	85	12.11	47	84	11.62	45	82	11.12
112	53	91	14.84	51	90	14.28	49	88	13.70	47	87	13.12
116	54	95	16.87	52	94	16.21	50	93	15.62	48	91	14.98
120	55	100	19.05	53	98	18.37	51	97	17.69	49	96	16.96

RELATIVE HUMIDITY, DEW-POINTS AND GRAINS OF MOISTURE PER CUBIC FOOT

Barometric Pressure—30 Inches

Degrees Wet-Bulb Depression

Dry-Bulb Temp.	21°			22°			23°			24°		
	% Rel. Hum.	Dew- Point	Grs. per Cu. Ft.	% Rel. Hum.	Dew- Point	Grs. per Cu. Ft.	% Rel. Hum.	Dew- Point	Grs. per Cu. Ft.	% Rel. Hum.	Dew- Point	Grs. per Cu. Ft.
66	10	11	0.70	7	2	0.49	3	-11	0.21	0		
68	13	17	0.97	10	11	0.75	6	2	0.45	3	-11	0.22
70	15	22	1.20	12	17	0.96	9	11	0.72	6	2	0.48
72	18	26	1.53	15	22	1.28	12	17	1.02	9	11	0.77
74	20	30	1.81	17	27	1.54	14	23	1.27	11	18	1.00
75	21	32	1.96	18	29	1.68	15	25	1.40	12	21	1.12
76	22	34	2.12	19	31	1.84	16	27	1.55	13	23	1.26
77	23	36	2.29	20	33	1.99	17	29	1.69	14	26	1.39
78	24	38	2.47	21	35	2.16	18	31	1.85	16	28	1.64
79	25	40	2.65	22	37	2.33	19	34	2.01	17	30	1.80
80	26	42	2.74	23	39	2.52	20	36	2.19	18	32	1.97
81	27	43	3.04	24	41	2.71	21	38	2.37	19	34	2.14
82	28	45	3.26	25	42	2.91	22	39	2.56	20	36	2.33
83	29	47	3.48	26	44	3.12	23	41	2.76	21	38	2.52
84	29	48	3.58	26	46	3.31	24	43	2.97	21	40	2.59
85	30	50	3.82	27	48	3.44	25	45	3.18	22	42	2.80
86	31	52	4.07	28	49	3.68	26	47	3.41	23	44	3.02
87	32	53	4.33	29	51	3.92	26	48	3.52	24	46	3.25
88	32	55	4.46	30	52	4.18	27	50	3.76	25	47	3.48
89	33	56	4.74	31	54	4.45	28	51	4.02	26	49	3.73
90	34	57	5.03	31	55	4.59	29	53	4.29	26	51	3.85
92	35	60	5.49	32	58	5.02	30	56	4.71	28	54	4.39
94	36	63	5.99	33	61	5.49	31	59	5.16	29	57	4.82
96	37	66	6.52	35	64	6.17	32	62	5.64	30	60	5.29
98	38	68	7.10	36	66	6.72	34	64	6.35	32	63	5.98
100	39	71	7.71	37	69	7.31	35	67	6.92	33	65	6.52
104	41	76	9.07	39	74	8.63	37	72	8.19	35	71	7.75
108	43	81	10.63	41	79	10.14	39	77	9.64	37	76	9.15
112	44	85	12.26	42	84	11.68	40	82	11.10	38	81	10.54
116	46	90	14.33	44	88	13.69	42	87	13.04	40	86	12.40
120	47	94	16.28	45	93	15.60	43	92	14.92	41	90	14.24
Dry-Bulb Temp.	25°			26°			27°			28°		
	% Rel. Hum.	Dew- Point	Grs. per Cu. Ft.	% Rel. Hum.	Dew- Point	Grs. per Cu. Ft.	% Rel. Hum.	Dew- Point	Grs. per Cu. Ft.	% Rel. Hum.	Dew- Point	Grs. per Cu. Ft.
75	9	15	0.84	7	8	0.66	4	2	0.37	1	-23	0.09
76	11	18	1.06	8	12	0.77	5	4	0.48	3	-10	0.29
77	12	21	1.20	9	16	0.90	6	9	0.60	4	-2	0.40
78	13	24	1.34	10	19	1.03	8	13	0.82	5	5	0.51
79	14	26	1.48	11	22	1.17	9	16	0.95	6	10	0.64
80	15	28	1.64	12	24	1.31	10	20	1.09	7	13	0.77
81	16	31	1.80	13	27	1.47	11	22	1.24	9	17	1.02
82	17	33	1.98	14	29	1.63	12	25	1.40	10	20	1.16
83	18	35	2.16	15	31	1.80	13	27	1.56	11	23	1.32

**RELATIVE HUMIDITY, DEW-POINTS AND GRAINS OF MOISTURE
PER CUBIC FOOT**
Barometric Pressure—30 Inches

Degrees Wet-Bulb Depression												
Dry-Bulb Temp.	25°			26°			27°			28°		
	% Rel. Hum.	Dew- Point	Grs. per Cu. Ft.	% Rel. Hum.	Dew- Point	Grs. per Cu. Ft.	% Rel. Hum.	Dew- Point	Grs. per Cu. Ft.	% Rel. Hum.	Dew- Point	Grs. per Cu. Ft.
84	19	37	2.35	16	34	1.98	14	30	1.73	12	26	1.48
85	20	39	2.55	17	36	2.17	15	32	1.91	13	28	1.66
86	21	41	2.76	18	38	2.36	16	34	2.10	14	31	1.84
87	22	43	2.98	19	40	2.57	17	36	2.30	15	33	2.03
88	22	45	3.07	20	42	2.79	18	38	2.51	15	35	2.09
89	23	46	3.30	21	44	3.02	19	41	2.73	16	37	2.30
90	24	48	3.55	22	45	3.25	19	43	2.81	17	39	2.52
92	25	51	3.92	23	49	3.61	21	46	3.30	19	43	2.98
94	27	55	4.49	24	52	3.99	22	50	3.66	20	47	3.33
96	28	58	4.94	26	55	4.58	24	53	4.23	22	51	3.88
98	29	61	5.41	27	58	5.04	25	56	4.67	23	54	4.29
100	30	63	5.93	28	61	5.54	26	59	5.14	24	57	4.74
104	33	69	7.30	31	67	6.86	29	65	6.42	27	63	5.98
108	35	74	8.65	33	72	8.16	31	71	7.66	29	69	7.17
112	36	79	9.98	35	78	9.42	33	76	8.86	31	74	8.58
116	38	84	11.78	36	83	11.16	34	81	10.56	33	79	10.25
120	40	89	13.90	38	87	13.20	36	86	12.49	34	84	11.79

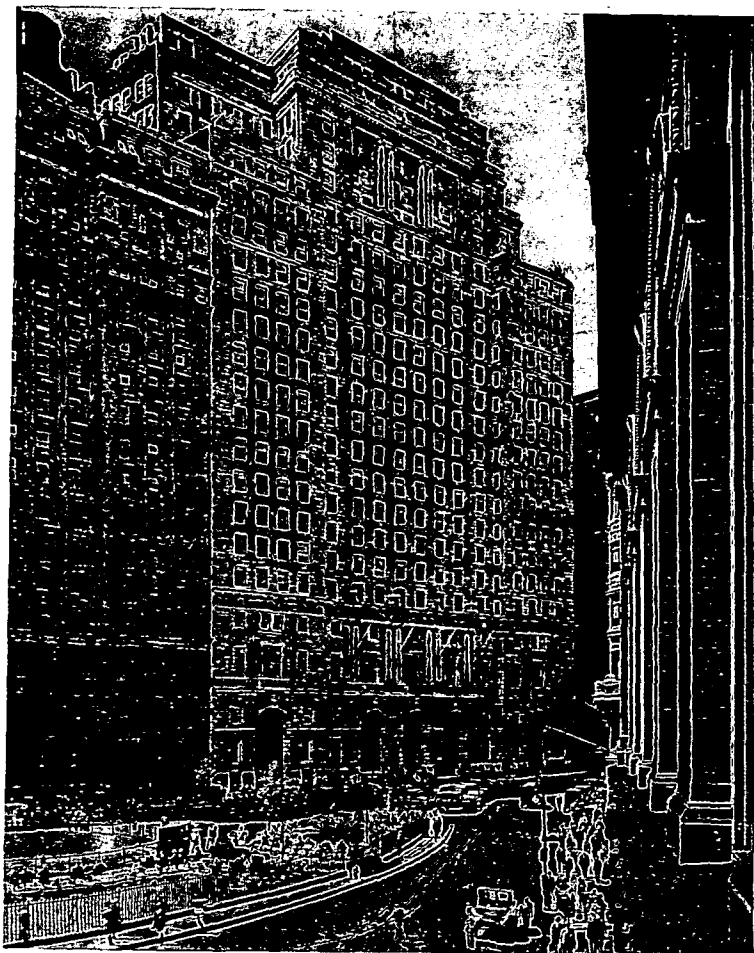
Dry-Bulb Temp.	29°			30°			31°			32°		
	% Rel. Hum.	Dew- Point	Grs. per Cu. Ft.	% Rel. Hum.	Dew- Point	Grs. per Cu. Ft.	% Rel. Hum.	Dew- Point	Grs. per Cu. Ft.	% Rel. Hum.	Dew- Point	Grs. per Cu. Ft.
78	3	-9	0.31									
79	4	-1	0.42	1	-20	0.11						
80	5	6	0.55	3	-7	0.33						
81	6	10	0.68	4	0	0.45	1	-18	0.11			
82	7	14	0.81	5	7	0.58	2	-6	0.23	0		
83	8	18	0.96	6	11	0.72	3	2	0.36	2	-15	0.24
84	9	21	1.11	7	15	0.87	5	8	0.62	3	-4	0.37
85	10	24	1.27	8	19	1.02	6	12	0.77	4	3	0.51
86	11	27	1.44	9	22	1.18	7	16	0.92	5	9	0.66
87	12	29	1.62	10	25	1.35	8	20	1.08	6	13	0.81
88	13	31	1.81	11	27	1.53	9	23	1.26	7	17	0.98
89	14	34	2.01	12	30	1.72	10	26	1.44	8	21	1.15
90	15	36	2.22	13	32	1.92	11	28	1.63	9	24	1.33
92	17	40	2.67	15	37	2.35	13	33	2.04	11	29	1.73
94	18	44	2.99	16	41	2.66	14	38	2.33	12	34	2.00
96	20	48	3.53	18	45	3.17	16	42	2.82	14	39	2.47
98	21	52	3.92	19	49	3.55	17	46	3.17	15	43	2.80
100	22	55	4.35	21	52	4.15	19	50	3.76	17	47	3.36
104	25	61	5.53	23	59	5.09	21	57	4.65	20	54	4.43
108	27	67	6.67	25	65	6.18	24	63	5.93	22	61	5.44
112	29	72	8.03	27	71	7.49	26	69	7.22	24	67	6.68
116	31	78	9.61	29	76	8.99	28	74	8.68	26	73	8.06
120	33	83	11.44	31	81	10.73	29	80	10.04	28	78	9.70

MODERN ENGINEERING AND EQUIPMENT PRACTICE

AS EXEMPLIFIED IN ACTUAL CONSTRUCTION

The purpose of this section is to present some of the modern buildings installed in the United States during the past few years in order to exemplify the present methods of heating and ventilation, and the equipment used. It is hoped that this section will illustrate practical applications of the theory given in the Data Section. Those responsible for this book regret that the difficulties surrounding this, our initial issue, have unavoidably restricted the number and type of installations covered. This is due to the short time available for obtaining and compiling this information. It is hoped in future editions of THE GUIDE to amplify and greatly improve this section. In order to do this every Member of the Society must co-operate, as the Committee in charge can only compile and edit the data furnished by Members.

All Members of the Society are requested to send pictures and data covering representative buildings; so that for the 1923 Issue a large list may be available for selection. There is no charge for this Section.



Cunard Building

CUNARD BUILDING

25 BROADWAY

NEW YORK, N. Y.

Office Building; 216 feet by 220 feet; Twenty-two stories; 12,700,000 cubic feet, volume of building; 228,000 sq. ft., wall surface; 86,000 sq. ft., glass surface; 47,520 sq. ft., floor area.

Heating System—Two-pipe vacuum.

Radiation—70,000 square feet direct.

Boilers—Five 175 H.P., low pressure, and one 30 H.P. medium pressure, horizontal return tubular.

Stoker Equipment—Hand fired mechanical with provisions made for future stokers and oil fuel.

Vacuum Pumps—Motor driven.

Automatic Temperature Control—Principal offices of the Cunard Steamship Co., and ventilation.

Ventilation—Ventilation is provided for the Banks; the Cunard Steamship Co. offices in basement, first, second, third floors and all toilets.

Temperature and Humidity Regulation—70° temperature. No humidity control.

Fans—Supply fans of 121,700 cubic feet per minute capacity. Exhaust fans of 193,200 cubic feet per minute capacity.

Number of water closets, 468; toilet lavatories, 152; office lavatories, 752; urinals, 205; slop sinks, 80; bath tubs, 2; laundry trays, 4; kitchenette sinks, 3; showers, 5; plumbing stacks, 31; leaders, 16; fire stand pipes, 5.
(3" 8"; 2" 4" with 100 feet of hose at each outlet at each floor.)

House Tanks—Two, 10,000 gal. steel.

Suction Tank—One, 2 compartment 10,000 gal. steel.

House Pumps—Two, 250 g.p.m. each.

Fire Pump—One, 750 g.p.m.

Hot Water Circulating Pump—For quick circulation.

Hot Water Generators—Three units 700 gal., storage type, capacity 3,000 gal. per hour, each.

Sump Pumps—Two duplex units, one unit 500 g.p.m., one unit 300 g.p.m.

Ejectors—Two cylinders, each 150 g.p.m. capacity.

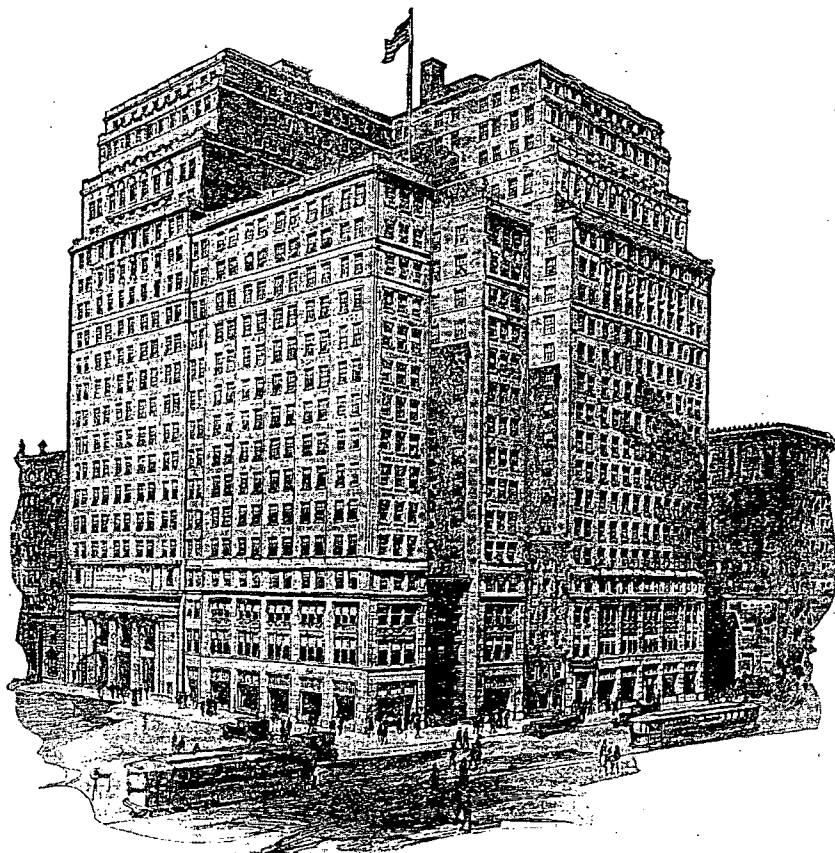
Air Compressors—Two units, each 200 c.f.m. capacity.

Elevators—Gearless Traction:

- 10 Broadway, local 1st to 14th floors inclusive.
- 8 Broadway, express 1st and 12th to 20th inclusive.
- 2 Broadway, local all floors.
- 4 Morris Street, locals Morris St. to 14th floor inclusive.
- 4 Morris Street, express Morris St. and 12th to 21st floors, incl.
- 2 Broadway, service all floors to roof.

Geared Traction:

- 2 Bank locals—5 floors.
- 3 Cunard locals—5 floors.
- 1 Sidewalk.
- 1 Ash hoist.
- 1 Dumbwaiter.



Canadian Pacific Building

CANADIAN PACIFIC BUILDING

WEST SIDE MADISON AVENUE, BETWEEN 43RD AND 44TH STREETS
NEW YORK, N. Y.

Office Building, with Christian Science Church occupying 650,000 cubic feet, at the southwest corner of the building; twenty-one stories; volume of building, 6,000,000 cu. ft.; wall surface (without glass), 197,000 sq. ft.; glass surface, 67,300 sq. ft.; maximum floor area, 28,000 sq. ft.; cost of building, \$6,500,000.00; cost of heating equipment, \$225,000.00; cost of plumbing equipment, \$200,000.00.

Heating System—Heated by down-feed vacuum system. The Church is heated by direct radiation and ventilation.

Boilers—Four, 250 H.P. each, portable fire box.

Vacuum Pumps—Three, 65,000 sq. ft. each.

Toilet Exhaust Fan—15,000 cu. ft. per minute.

Radiation—68,500 sq. ft. direct.

Stoker Equipment—Hand fired.

Automatic Temperature Control—Church (ventilation and radiation).

Parts Ventilated—Principal parts of Church and all Toilet Rooms throughout building. Air changed for Church Auditorium eight times per hour. Air changed for Toilet Rooms ten times per hour.

Temperature and Relative Humidity of Air Supplied—Temperature, 70°; humidity, 60%.

Ventilation System—Church, 48,000 c.f.m., air washer; 48,000 c.f.m., supply fan; 40,000 c.f.m., exhaust fan. These two fans supply and exhaust air for Church, Auditorium, Sunday School rooms and other principal parts of Church.

Special Equipment—

a. **Hot Water**—700 gal. storage tank; 700 gal. per hour steam coil; 500 gal. per hour summer heater.

b. **Fire Service**—Two 6-inch stand pipes with 100 ft. hose at each outlet at each floor.

c. **Express Elevators**—Six 1 to 1 traction.

d. **Local Elevators**—Six geared traction.

e. **Size of Elevators**—6'2" wide, 5'3" deep.

f. **Speed of Elevators**—Express, 600 feet per minute. Local, 500 feet per minute.

Plumbing Fixtures—Number of Lavatories: men, 55; women, 50. Water closets: men, 125; women, 75. Urinals, men, 70. Lavatories in offices, 195. Slop sinks, 30. Showers, 2.

FEDERAL RESERVE BANK

EAST SIDE OF EAST 6TH STREET
BETWEEN SUPERIOR AVENUE AND ROCKWELL AVENUE
CLEVELAND, OHIO

Bank on first floor, about 250 office rooms above, security vaults in basement and sub-basement, a gymnasium, recreation room, cafeteria, storage space and security court; building 200 ft. long and 150 ft. wide; fourteen stories; volume of building, 6,500,000 cu. ft.; wall surface, 80,500 sq. ft.; glass surface, 31,100 sq. ft.; floor area, 30,000 sq. ft.; cost of building, \$5,500,000.00; total cost of mechanical equipment, \$500,000.00.

Heating System—Two-pipe down-feed vacuum system, using exhaust steam from engines and pumps.

Radiation—40,000 sq. ft. direct.

Boilers—Four 300 H.P. high pressure water tube boilers with superheaters.

Stoker Equipment—Natural draft stokers of "V" type.

Vacuum Pumps—Two, motor driven; capacity, 100,000 sq. ft. direct radiation each.

Automatic Temperature Control—All radiation and ventilation.

Power Plant Equipment—Three 300 K.W. generators direct-connected to three uni-flow steam engines.

Ventilation—Practically throughout.

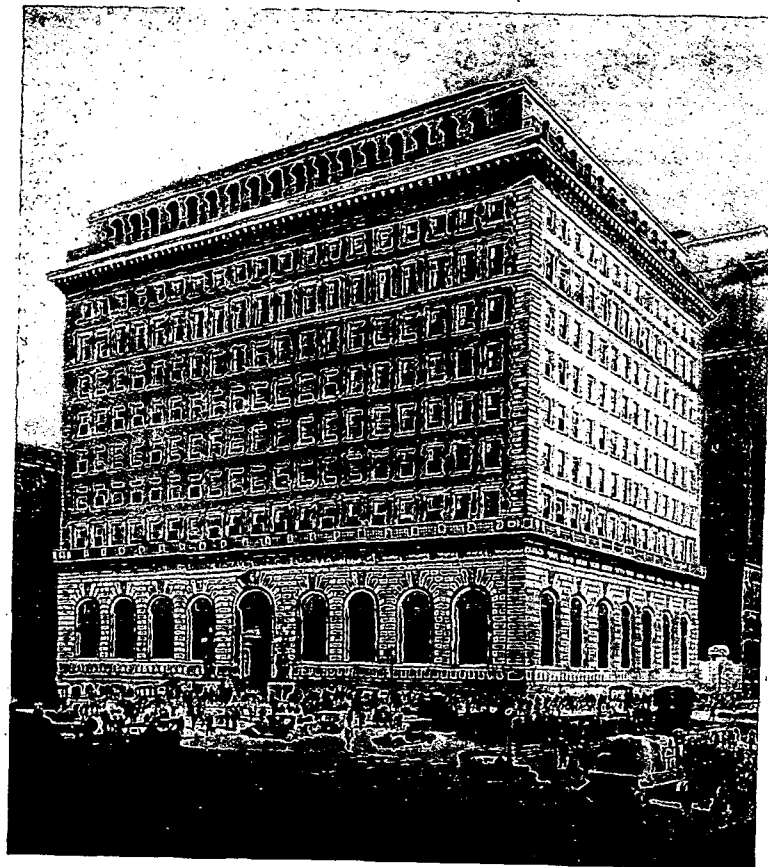
Air Changes—Four per hour for office rooms. For other rooms varies from 4 to 20 per hour, depending upon purpose for which rooms are used.

Temperature and Relative Humidity—In sub-basement, basement and part of ground floor air supplied at 85° and 60%. For other floors, 70° and 60%.

Supply Fans—Twelve, total capacity 334,000 cu. ft. per minute.

Exhaust Fans—Fifteen, total capacity 197,400 cu. ft. per minute.

Air Washers—Eleven, total capacity 334,000 cu. ft. per minute.



Federal Reserve Bank of Cleveland

OSGOOD-BRADLEY BUILDING

GRAFTON AND FRANKLIN STREETS
WORCESTER, MASS.

Factory Building; concrete with brick and concrete exterior, terra cotta first floor; length, 100 ft.; width, 200 ft.; eight stories and basement; volume of building, 2,175,800 cu. ft.

Heating System—All parts heated by vacuum system.

Radiation—17,900 sq. ft. direct.

Boilers—Two, 150 H.P., H.R.T. boilers; 72" diameter x 18' long.

Temperature Ranges—Maximum, 70°F.

Vacuum Pumps—5½" x 8" x 7".

Elevators—Two passenger cars 2,500 lbs., 200' per min. electric. Three freight cars 3,500 lbs., 150' per min. electric.

Sprinkler Equipment—1929 heads.

E. W. BLISS MACHINE SHOP

BLISS ROAD
CLEVELAND, OHIO

Factory Building; length, 370 ft.; width, 120 ft.; height, 55 ft.; one story; volume of bldg., 1,620,000 cu. ft.; wall surface, 3,800 sq. ft; glass surface, 24,500 sq. ft.

Heating System—All parts heated. Hot blast used.

Boilers—Two, 150 H.P. each.

Temperature Ranges—Maximum, 60°F. Minimum, -10°F.

Parts Ventilated—All parts.

Ventilating Equipment—Two, 45,000 cu. ft. per minute, multivane type fans, belt driven.

Air Washers—Two, 45,000 cu. ft. air washers delivering air at 125° and final humidity of 60%.

Vacuum Pumps—Capacity in sq. ft. of radiation, 50,000.

CAPITOL THEATRE

SOUTHWEST CORNER BROADWAY AND 51ST STREET
NEW YORK CITY

Theatre with office building connected. Volume of building, 1,100,000 cu. ft. in theatre proper, 2,000,000 cu. ft. gross; plot area, 200' north and south, 321' east and west, with 90' x 90' corner out at south-east corner of lot; cost of building, \$1,125,000.00; cost of heating and ventilating equipment, \$70,000.00, including heating of office building.

Heating System—Up-feed gravity system and ventilation; 9,000 sq. ft. direct radiation, including office building.

Boilers—Three, 135 H.P. each, portable fire box.

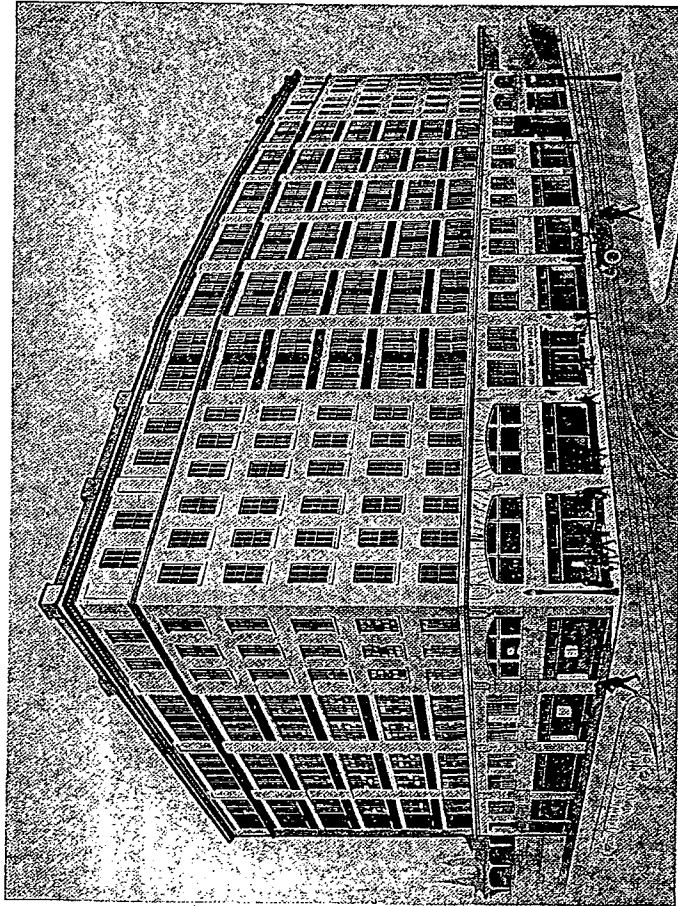
Stoker Equipment—Hand fired.

Automatic Temperature Control—Ventilation and radiation.

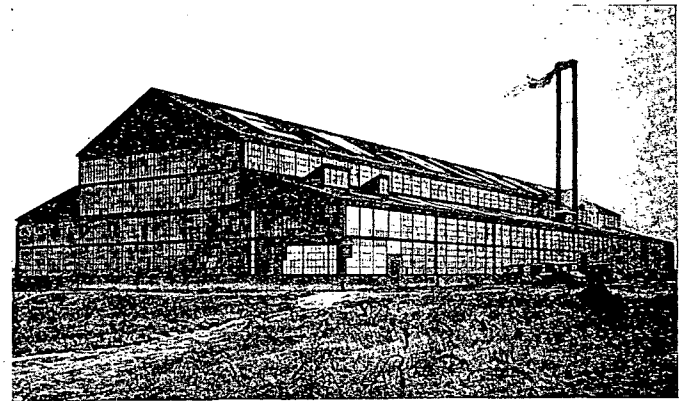
Parts Ventilated—Auditorium, 11 air changes per hour; Toilets, 12 air changes per hour.

Temperature and Relative Humidity—70° and 40%.

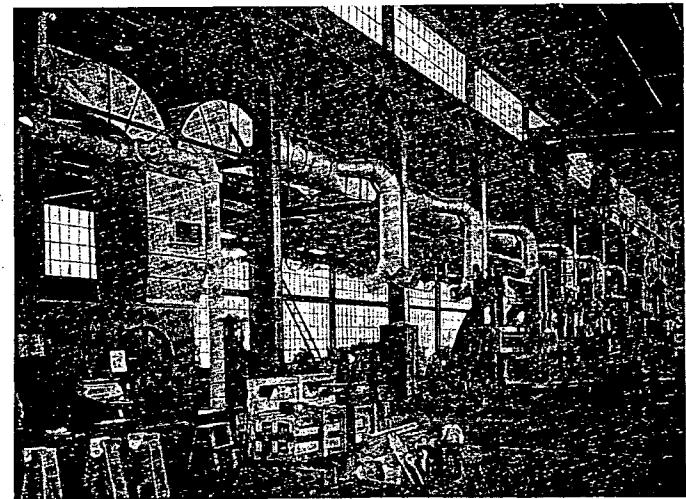
Ventilation System—Two supply fans, 75,000 c.f.m. each; one supply fan, 6,000 c.f.m. each; two exhaust fans, 75,000 c.f.m. each; two toilet fans, 7,000 c.f.m. each; two air washers, 75,000 c.f.m. each.



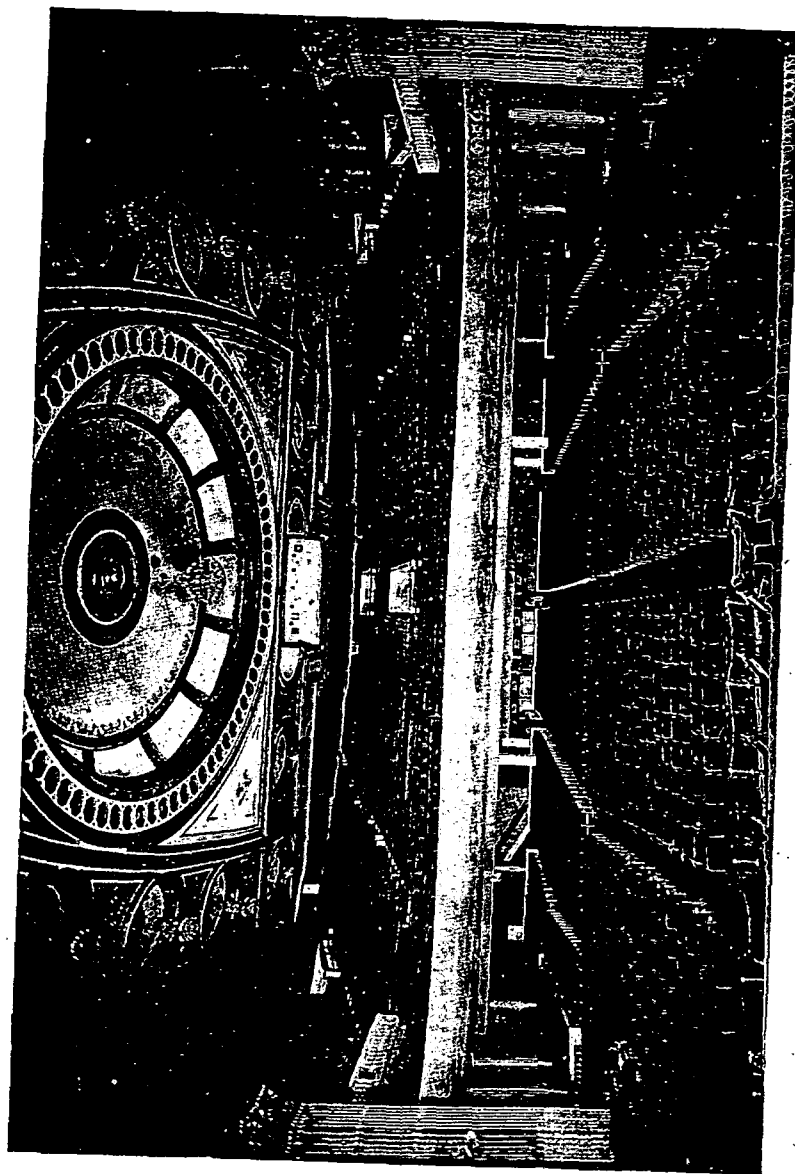
Osgood-Bradley Building



E. W. Bliss Co.



View of Heating System.
E. W. Bliss Co.



Capitol Theatre

METROPOLITAN LIFE INSURANCE COMPANY PRINTING BUILDING

JACKSON AVENUE, LONG ISLAND CITY

NEW YORK, N. Y.

Factory Building; reinforced concrete. Triangular shape with center court, containing about 60,000 sq. ft. per floor. Length, 530 ft.; width, 395 ft.; height, 75 ft.; six and one half stories; volume of building, 5,940,000 cu. ft.; maximum floor area, 390,000 sq. ft.; cost of heating and ventilating equipment (approx.), \$172,000.00.

Heating System—All parts heated by vacuum system.

Radiation—60,000 sq. ft. direct.

Boilers—Four 200 H.P. smokeless portable. One smaller for summer use.

Temperature Ranges—Maximum, 70°F.

Temperature Control—Automatic thermostatic.

Parts Ventilated—Switchboard and transformer room.

Ventilating Equipment—One 36" multivane type fan, handling 6,000 cu. ft. at ¼" resistance with 1 H.P. motor direct connected.

Vacuum Pumps—Two, 10"x14"x12".

Hot Water System—Two heaters, 36"x10', 1,000 gal. per hour; two house tanks, 15,000 gal. each.

Elevators—Two hydraulic plunger 3,000 lbs. basement to 1st. Seven electric geared traction machines 100 and 200' per minute. Automatic levelling device on all electric elevators.

Electrical Accessories—Battery charging; dictagraph lamp annunciators; program time clocks; fire alarm; inter-office telephones; signal call bell system; electrostatic neutralizer.

CHAS. M. JORDAN JUNIOR HIGH SCHOOL

28TH ST. AND JAMES AVE. NORTH

MINNEAPOLIS, MINN.

Junior High School; \$540,000.00, approx. cost of building; cost of heating and ventilating equipment, \$60,547.00; length, 352 ft.; width, 260 ft.; height, 44 ft.; two stories and basement; 2,554,203 cu. ft. volume of building.

Heating System—All parts heated by Direct Radiation.

Temperature Ranges—Maximum, 68°F. Minimum, 30°F.

Temperature Control—Automatic.

Parts Ventilated—All ventilated, mechanical system.

Ventilating Equipment—9 fans, capacity 127,000 cu. ft. per minute, belt driven, equipment in basement. Six to eight air changes per hour.

Parts Air Conditioned—Auditorium, gymnasium, swimming pool rooms, all class rooms and laboratories. Two units located in basement. Capacity, 74,000 cu. ft. per minute. Six to eight air changes per hour. Temperature, 68°F. Humidity, 55% R.H. Closed heater with automatic control.

Total Direct Radiation—18,000 sq. ft.

Boilers—3 D.D. Fire Box Boilers. Combined rating 42,000 RAD.

Vacuum Pumps—Two, capacity 40,000 sq. ft. each.

Hot Water System—60"x120" Service Heater and Storage Tank, capacity 1,770 gallons per hour, 50°F. to 150°F., 3" steam, 2" water.

Water Treatment—Violet Ray—Pool.

Refrigerating Equipment—Ammonia—self-contained.

Elevators—One 6x6 Car Switch type—Freight, 100 ft. speed.

Dumbwaiters—One, 20x24.

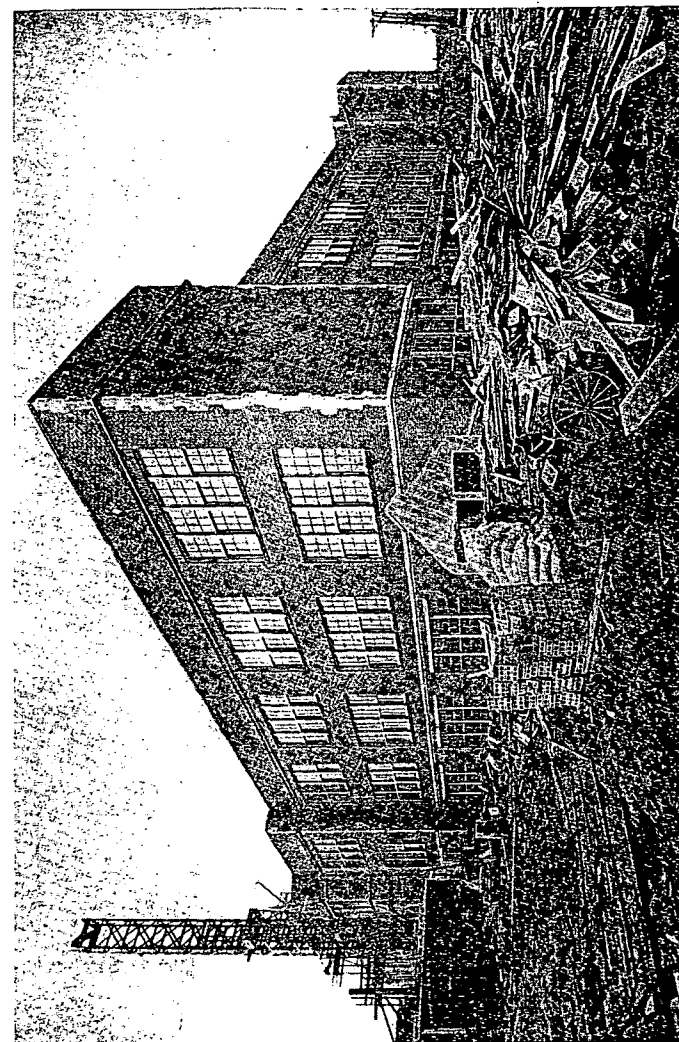
Electrical Accessories—Clocks, fire alarms, program bells, scenic stage lighting.

Electric motor drive for all machinery.

Sprinkler Equipment—On stage.



Metropolitan Life Insurance Company
Printing Building



Chas. M. Jordan Junior High School

TYPICAL SCHOOL BUILDING OF LARGE SIZE

Steel framing, brick walls with 2" T.C. furring on inside; wooden floors in rooms; T.C. partitions; furred roof; width, 60 ft.; height, 85 ft.; five stories and cellar; cost of building (approx.), \$1,000,000.00; cost of heating and ventilating equipment (approx.), \$90,000.00.

Heating System—All parts heated except cellar. Hot blast used for auditorium. Direct radiation (steam) for all other parts. (Vacuum system.)

Radiation—15,000 sq. ft. direct.

Boilers—Four, each 1,303 sq. ft. of heating surface. Internally fired, return tubular pattern.

Temperature Ranges—Maximum, 68°F. Minimum, 62°F.

Temperature Control—Automatic in all occupied rooms.

Parts Ventilated—All occupied parts. Plenum and exhaust.

Ventilating Equipment—Supply, 4 blowers: 2 in classrooms and corridors, each 48,500 cu. ft. per minute. Auditorium, 22,800 cu. ft. per minute. Playroom and Gymnasium, 35,650 cu. ft. per minute.

Exhaust, 7 units: Classrooms, 2, each 39,000 cu. ft. per minute. Auditorium, 19,030 cu. ft. per minute. Playroom, 27,200 cu. ft. per minute. Toilets, 2, one of 3,200 and one of 2,200 cu. ft. per minute. Kitchen, 550 cu. ft. per minute. (Shower baths and pools, often add units.) All electric motor driven, mostly belted. Supply units in cellar, exhaust units in roof houses or cellar. Classrooms, etc., about 5 minute changes. Toilets and lavatories, 4 minute changes.

Vacuum Pumps—Each with a capacity in sq. ft. of 65,000. (Duplicate units furnished.)

Hot Water System—Suction tank and storage, each 500 gal. Heater, 800 gal. per hour. Where shower baths occur added units are used.

Dumbwaiters—Hand type dumbwaiter for handling books, etc.



HORTICULTURAL GROUP, LONGWOOD, INC., ESTATE OF PIERRE S. DU PONT

LONGWOOD NEAR MENDENHALL, PA.

Growing Houses (Typical green house construction)—Total area, 22,000 sq. ft.; volume, 196,000 cu. ft.; wall surface, 4,800 sq. ft.; glass surface, 36,600 sq. ft.; direct radiation, 7,900 sq. ft. (pipe coils); average temperature, 60°F.

Main Building (including orangerie, exhibition hall, peach houses, display houses and organ loft)—Total area, 44,000 sq. ft.; volume, 1,130,000 cu. ft.; wall surface, 20,000 sq. ft.; glass surface, 64,000 sq. ft.; direct radiation, 8,500 sq. ft. (concealed); gravity ind. radiation, 12,000 sq. ft. (in tunnel); primary ind. radiation, 3,400 sq. ft. (in fresh air intakes); average temperature, 65°F.

Reception Suite (underground in terrace, one wall only exposed, tunnel to main building)—Size, 65x54, one story; area, 3,500 sq. ft.; volume, 56,000 cu. ft.; wall surface, 6,600 sq. ft. (75% against earth); glass surface, 450 sq. ft.; heating surface, 450 sq. ft. (tempering and heater coils); temperature, 70°F.

Service Building (basement-storage (not heated) first floor, office and work rooms, second floor, living quarters)—Size, 70x60 plus wings; area, 5,200 sq. ft.; volume, 90,000 cu. ft.; wall surface, 6,600 sq. ft.; glass surface, 2,000 sq. ft.; radiation, 1,550 sq. ft.; temperature, 70°F.

Note—Boiler plant located under terrace in front of Service Building.

Cost of Building (approx.)—\$1,850,000.00.

Cost of Heating and Ventilating Equipment (approx.)—\$160,000.00.

Heating System—All parts heated with vacuum system, direct radiation in Growing Houses and Service Bldg., gravity indirect and part direct in Rose House and Main Bldg.; Reception Suite hot blast separate duct system.

Parts Not Heated—Store rooms in basement of Service Building.

Radiation—18,000 sq. ft. direct, 12,000 sq. ft. gravity indirect, 3,000 gravity tempering (equivalent direct radiation 40,000 sq. ft.).

Boilers—Four 110 H.P. water tube, set in single battery, 8'6" floor to header, designed for fuel oil.

Temperature Ranges—Maximum, 75°F. Minimum, 40°F.

Temperature Control—Hand in Growing Houses and bed rooms of Service Building, automatic for Rose House, Main Building, reception suite and working space of Service Building.

Parts Ventilated—Reception Suite hot blast divided duct system, automatic temperature control on by-pass dampers.

Ventilating Equipment—Reception Suite one blower 3,600 cu. ft., motor belt drive; about 2½ air changes. Two exhaust fans, propeller type, direct connected motors, each fan 1,600 cu. ft. per minute.

Parts Not Ventilated—Growing Houses and Main Building not mechanically ventilated, but have sash ventilation, fresh air intake in connection with gravity indirect systems.

Humidity—In Main Building; Orangerie, Exhibition Hall and Organ Loft are equipped with pan humidifiers with steam coils at each indirect heater in tunnels; 39 units, 23,000 cu. ft. per minute, 65°F. at 70% relative humidity, room type humidistats operating diaphragm valves in steam main to pan humidifiers.

Stoker Equipment—Fuel oil furnaces, oil storage consists of 300,000 gal. concrete reservoir underground with gravity supply line 400 ft. to service tank at Boiler House, oil equipment includes pumps, heaters, automatic temperature control for oil in storage.

Vacuum Pumps—Two 8"x10"x12" steam, 900 sq. ft. each.

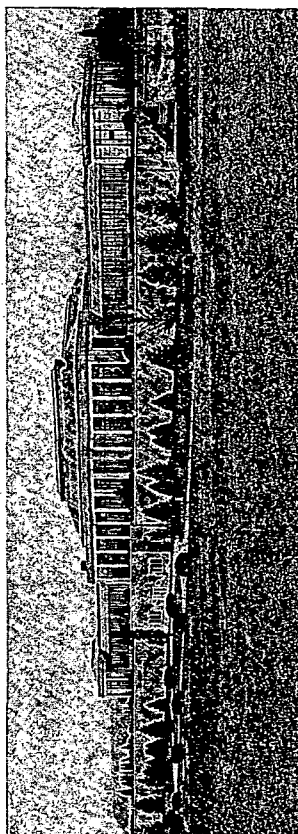
Hot Water System—Domestic hot water Service Building, copper tube storage tank heater 200 gal. per hour. Tempered water 1,100 gal., tank cap. 5,000 gal. water per hour 35°F. to 65°F. with temperature control.

Elevators—Elevator special design with track for industrial car used in Green Houses.

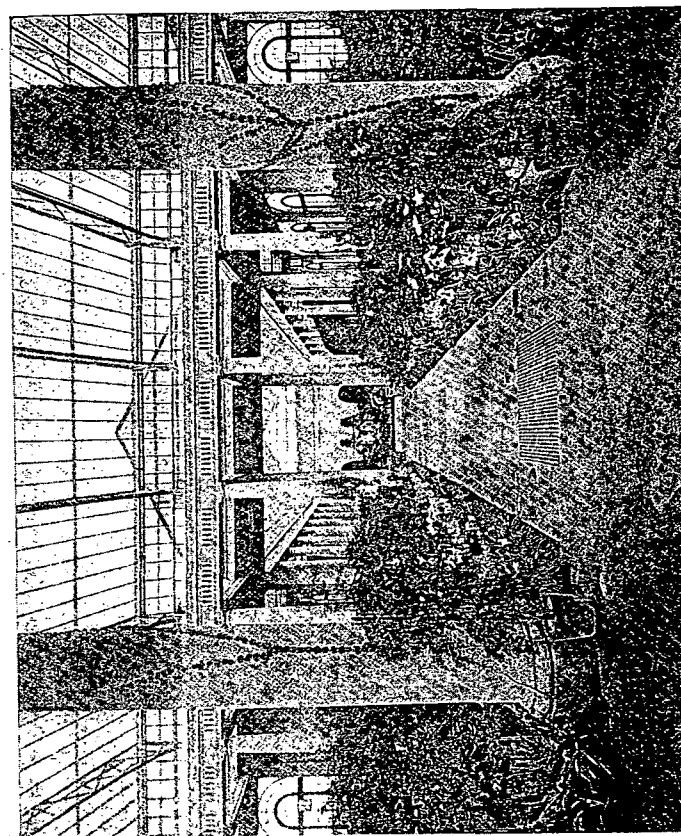
Escalators, Dumbwaiters, Etc.—In Orangerie and Exhibition Hall, Main Building, ventilating sash equipment with 22 remote control motor driven sash operating mechanisms.

Electrical Accessories—Main switch board 2,200 volt incoming service transformers at Service Building for Growing House; 2,200 volt to Main Building, separate transformer station; special remote control for lighting in Orangerie and Exhibition Hall. Theatre dimmers for Exhibition Hall and Stage.

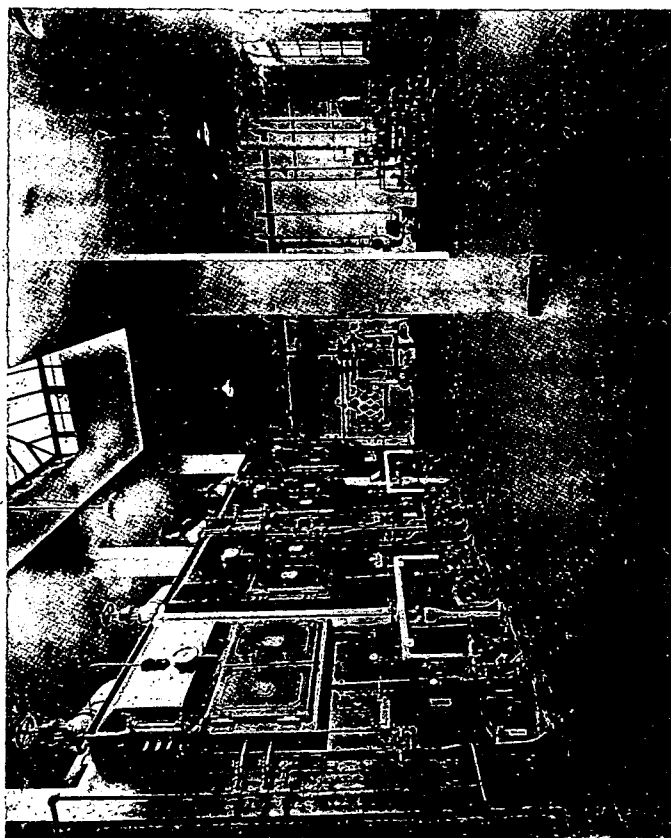
Additional Data—So far as known, this is the largest horticultural group undertaken by a private estate and the first application of gravity indirect heating and temperature control as in Rose House and Main Building. Thermostats special in waterproof boxes. Boiler plant and facilities provide for increase to present buildings.



Main Building, Rose House at Left
Estate of Pierre S. duPont



View Through Orangerie
Estate of Pierre S. duPont



Boiler Plant in Service Building
Estate of Pierre S. duPont

Directory
of
Consulting Engineers
in
Heating & Ventilating

CLARK, MACMULLEN & RILEY, INC.

Consulting Engineers

Design and Supervision

Heating, Ventilating, Plumbing and Electrical

Industrial Sites Selected

Factory Buildings Designed

NEW YORK, 101 Park Avenue

CLEVELAND, Marion Building

WALTER S. TIMMIS, M. E.

315 FIFTH AVENUE, NEW YORK

Member American Society Mechanical Engineers

President American Society Heating and Ventilating Engineers

Complete Building Equipment Engineering

Heating and Ventilation

Power Plants

Electrical Work

Plumbing

Sprinkler Systems

Elevators

Examinations

Reports and Tests

Seismograph Tests for Building Vibration

SAMUEL E. DIBBLE

Consulting Engineer

Heating

Ventilating

Sanitation

3307 PARKVIEW AVENUE

PITTSBURGH, PA.

Member A. S. M. E.

Member A. S. H. & V. E.

ROBERT P. SCHOENIJAHN

Consulting Engineer

Industrial Trust Bldg., WILMINGTON, DEL.

Reports

Designs

Supervision

Mechanical Equipment of Structures

Power Plants

Heating and Ventilating

Plumbing

Sanitation

Refrigeration

Electrical Equipment

FREDERICK D. MENSING

SAMUEL M. DODD

MENSING & CO.

Consulting Engineers

Presser Building

PHILADELPHIA

CATALOG DATA
SECTION

INDEX TO ADVERTISERS

AND

INDEX TO MODERN EQUIPMENT

IN LAST PAGES OF BOOK

ATMOSPHERIC CONDITIONING CORPORATION

General Western Office
841 Monadnock Block
Chicago

Main Office
921 Lafayette Building
Philadelphia

Territorial Offices in the Principal Cities of the United States
Also Throughout Canada and London, Eng.

Humidifying, Dehumidifying, Cleansing, Cooling, Humidity Control

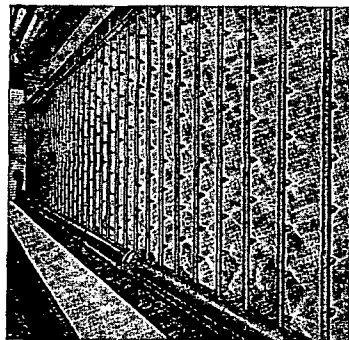
Modern Ventilation

Modern Ventilation practice demands the removal of dust and foreign matter from incoming air whether it be for insuring comfort or providing healthful conditions for audience, student or employee and applies to efficiency and accuracy in many manufacturing processes.

Of more importance however is the maintenance of the proper relative humidity by the addition or removal of moisture from the air according to season or local conditions.

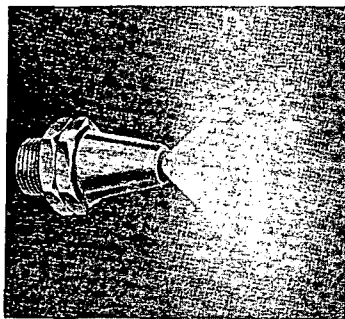
The design, manufacture and in some cases the installation of air conditioning apparatus in many types of buildings is our sole undertaking and during fifteen years of research and practice we have furnished hundreds of equipments with remarkable results.

In Schools, Auditoriums, Theatres, Ball Rooms, Dining Rooms, Cafes, Court Rooms and all spaces where people gather in large numbers our type of equipment has become essential.



View of Spray Chamber showing nozzles in operation.

216



Webster Spray Nozzle used in all atmospheric installations.

Humidifiers have been furnished for producing and maintaining the proper relative humidity.

Dehumidifiers have been installed in Industrial Plants where excessive humidity must be removed, for drying or process work. This being accomplished either by evaporation of the spray water or the use of artesian well water.

In many cases it is found necessary to resort to refrigeration and in this type of equipment we have excelled.

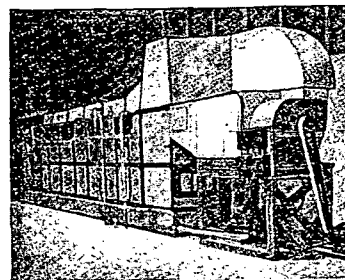
Equipment for Maintaining Artificial Atmospheric Conditions in Industrial Plants

The addition of the proper percentage of humidity to make up deficiency.

The removal of excessive humidity when high moisture content in the air prevents proper drying or carrying out of certain processes.

Maintaining either high or low temperatures where local conditions or specific materials demand such treatment.

The maintenance of uniform humidity conditions within 2% of that for which control is set.



Air Conditioning apparatus, a duplicate of which was furnished after one season's trial of first installation.

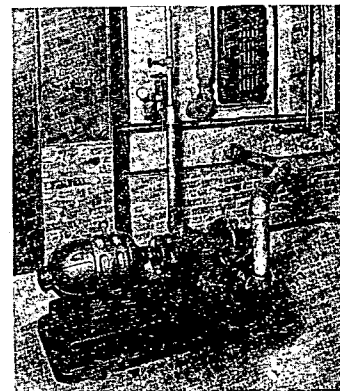
The maintenance of working spaces at the Comfort Zone to insure efficiency of employees.

The cleansing and cooling of air for the Ventilation of Turbo Alternators, equipment commonly known as Generator Coolers.

Webster Air Washers

Type "A" Apparatus, designed primarily for air washing in connection with ventilating systems in public buildings, where a moderate cooling effect by evaporation is desired.

Type "B" Apparatus, designed for air washing in public buildings and industrial plants, where the greatest possible cooling effect by evaporation is desired.



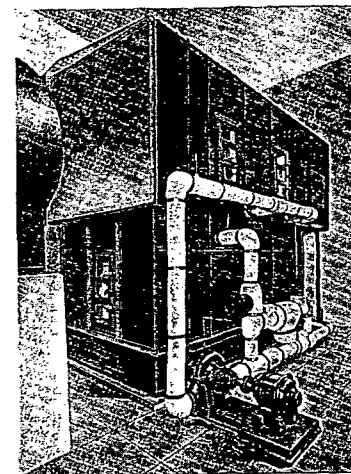
Type "A" Webster Air Washer equipped with humidity control.

Webster System of Humidity Control may be applied to the various types of Webster Air Washers, Humidifiers and Dehumidifiers. Perfect in principle and accurate in operation—the chief controlling thermostat subject to water, a medium with four times the specific heat of air.

Service

Each Air Conditioning problem is a separate study and it has been found impossible to set forth in catalogue or bulletin form such information as would apply to any specific case except in a general way.

We have such catalogues and bulletins as would give the prospective purchaser



Atmospheric Dehumidifier, in successful operation since 1918 in large plant manufacturing food products.

a general idea as to what the apparatus would consist but we find that in the end a personal interview is desirable.

We gladly render service to those interested, in the form of recommendations and quotations, no charge being made except for actual equipment furnished.

We will not undertake a contract where we cannot accomplish just the results the buyer wishes, but where we do accept an undertaking we will give our best thought and skill to its complete accomplishment.

217

Carrier Engineering Corporation

Office and Laboratories: 750 Frelinghuysen Ave.

Newark, N. J.

Boston, 176 Federal St.
Buffalo, Prudential Bldg.

New York, 39 Cortlandt St.
Chicago, Transportation Bldg.
Philadelphia, Land Title Bldg.

Carrier Engineering Co., Ltd.
24, Buckingham Gate, London

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. Design and installation of Industrial Piping. Manufactured Weather to make "Every day a good day."

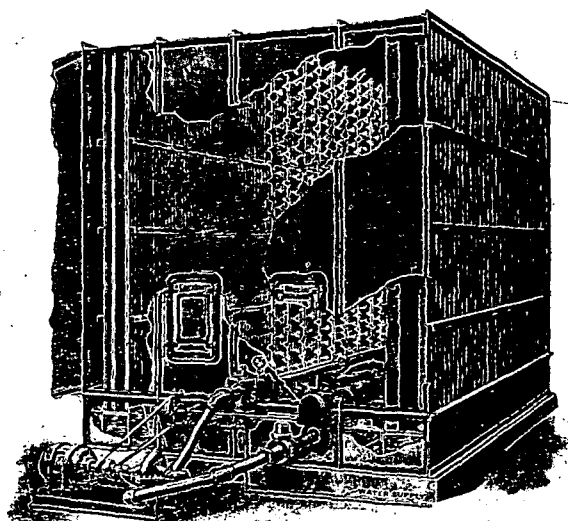
Air Conditioning is the science of mechanically regulating the (1) temperature, (2) humidity, (3) cleanliness and (4) effective distribution of the air within buildings or enclosures, such as dryrooms.

Based upon the pioneer research and invention of Willis H. Carrier during the last twenty years, this Corporation has developed scientifically effective and mechanically adequate equipment and automatic control for the conditioning of air. Carrier Equipment has been installed in more than one hundred distinctly different industries, as varied as the manufacture of chewing gum and cotton goods.

The tremendous fund of engineering and construction experience acquired in meeting these widely varying requirements enables us to offer a valuable service in the design of air conditioning equipment for any purpose.

The limitations of space herein preclude a complete technical description of the principles involved, the apparatus and the methods of automatic control employed.

Broadly, wherever weather or the variations of atmospheric temperature and humidity affect either the labor or the processes of manufacture, Carrier Equipment can be applied to make "Every day a good day."



Typical Carrier Humidifier, with Sprays in operation, showing Rotary Strainer (R) at Pump Inlet, Ejector Water Heater (E) in Pump Suction Line, Pump (P), Pump Motor (M), and Pot Strainer (S) in Pump Discharge Line.

Air enters the Humidifier at the right, thru the Distributor Plates, passes across the Spray Chamber where it is cleaned and saturated at the Spray Water temperature, and leaves the Machine thru the Eliminator Plates, which, by means of their wet surfaces, complete the Cleansing Action, and eliminate entrained or free moisture.

Manufactured Weather (as we generally speak of air conditioning) can be provided in exact accordance with specific requirements. Humidifying equipment provides air that is clean, heated to any desired degree in winter, cooled to the outdoor Wet Bulb temperature in summer, moistened as required, and distributed uniformly and effectively to the area wherein it is to perform its functions, whether this be an entire building, separate departments of a building, the interior of a dryer or enclosed machines.

Dehumidifying equipment, during the winter season, performs all the functions of humidifying apparatus and, in addition, by the use of naturally cold water or mechanical refrigeration, meets every summer requirement; providing any temperature desirable and any degree of humidity or moistness required. Thus dehumidifying equipment makes possible the uninterrupted production, in summer, or in localities where the climate is unfavorable, of those materials which are affected by temperature or humidity, or both. Or dehumidification will relieve excessive temperature and moisture conditions which affect the labor.

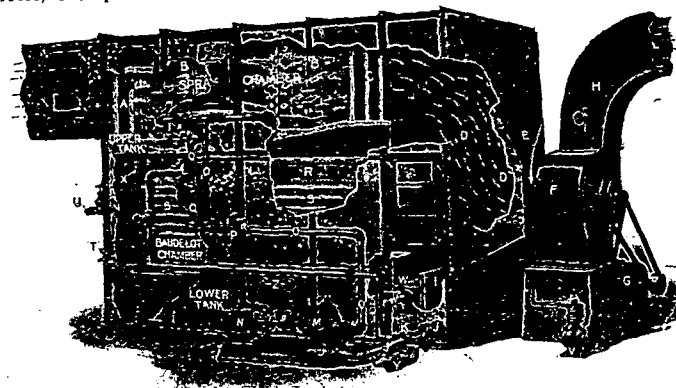
The application of Conditioned Air in Drying or Processing is becoming more and more important every day. Conditioned Air drying is a natural, efficient process, susceptible to accurate control

and remarkably flexible in its adaptability to given requirements. The most delicate products, both physically and chemically, can be processed or dried under automatic control, quickly and at minimum cost. For the more rugged product, where speed and cost are the principal factors, conditioned air drying or processing is, in nearly every instance, the most desirable and economical method available.

On account of the multiplicity of factors involved in a comprehensive explanation of our business, we publish, privately, a monthly magazine, *The Weather Vein*, which relates, not too technically, the constantly lengthening story of Manufactured Weather and its industrial applications. We invite any interested person to become a "regular subscriber." The subscription price is your request.

In addition to *The Weather Vein* we have published a number of Bulletins describing Carrier Apparatus and certain of its specific applications. These Bulletins are at your disposal, upon your request.

We invite you to avail yourself of the opportunity to become familiar with the principles and practice of scientific air conditioning, through our publications. Manufactured Weather has proven an invaluable ally in scores of industries, and the list is growing rapidly.



Typical Carrier Self-Contained Dehumidifier. A—Distributor Plates. B—Sprays. C—Eliminator Plates. D—Outlet. E—Fan Connection. F—Fan. G—Fan Motor. H—Fan Outlet Connection to Duct System. I—Pump Suction Screen. J—Pump Suction Line. K—Three-way Mixing Valve. L—Line from Upper Tank to Three-way Valve. M—Pump. N—Pump Motor. O—Pump Discharge Line. P—Pot Strainer. Q—By-pass to Upper Tank for quick cooling at start. R—Drip Troughs over Baudelot Coils. S—Baudelot Cooling Coils. T—Refrigerant Inlet. U—Refrigerant Outlet. V—Air Compressor for Automatic Control. W—Overflow from Lower Tank. X—Upper Tank Drain. Y—Lower Tank Drain to Sewer. Z—Fresh Water Connections for Make-up and Cleaning.

Air Conditioning

W. L. Fleisher & Co., Inc.

31 Union Square West

New York, N. Y.

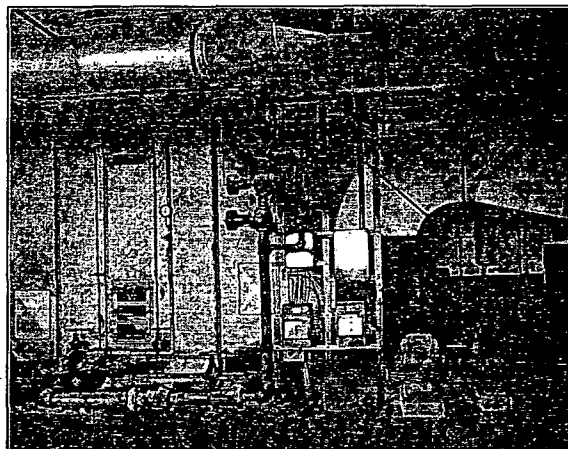
Chicago, Ill., 530 South Clinton St.

Philadelphia, Pa., 135 North 3rd St.

Consulting and Contracting Industrial Engineers for Air Conditioning and Drying

Sturtevant-Fleisher

AIR CONDITIONING SYSTEMS



The Sturtevant-Fleisher air conditioning systems cover the whole field of humidifying, dehumidifying, cooling and heating in all their branches. These systems are based on a combination of the 60 years' engineering and manufacturing experience of the B. F. Sturtevant Co., with the 10 years' industrial engineering and contracting experience of W. L. Fleisher & Co., Inc.

All Sturtevant-Fleisher air conditioning systems are composed of B. F. Sturtevant Co. apparatus exclusively, and are designed and installed by W. L. Fleisher & Co., Inc.

Systems are designed for estimating and installation only after exhaustive tests both in the Sturtevant-Fleisher laboratories and in the factory; all installations are covered by a guarantee to "Deliver the climate" which is ideal for the specific product.

A comprehensive engineering and construction organization carries the problem through from the preliminary investigation to the completed installation, turning the system over to the client in operation, with guarantees demonstrated.

Many prominent concerns have made use of our research laboratory; it is at the service of anyone who has difficult problems to solve by experimentation. Preliminary experimental work is furnished without charge.

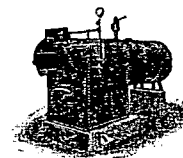
Boilers and Engines

Ames Iron Works

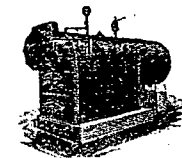
Oswego, N. Y.

Boilers for heating and power, Una-flow and heavy duty single valve engines, smokestacks, breechings, tanks.

Sixty-six years of boiler manufacturing experience is behind every Ames Boiler.



Plain Furnace Type



Downdraft Furnace Type

Ames Firebox Heating Boiler with Plain Furnace

No. of Size	Diam. Shell	Length Furnace	Width Furnace	Height Furnace Above Grates	Sq. Ft. Grate Area	Heating Surface Sq. Ft.	Capacity Steam Rad. Sq. Ft.	Capacity Water Rad. Sq. Ft.	Size Steam Outlet	Size Return	Diam. Chimney	Weight in Lbs. Boiler Complete
805	42"	42"	36"	34"	10.5	249	2500	3750	5"	3"	14"	7100
808	48"	42"	42"	37"	12.25	403	4000	6000	6"	4"	16"	9370
810	54"	48"	48"	40"	16.0	511	5150	7725	6"	4"	20"	10980
812	54"	54"	48"	40"	18.0	613	6500	9750	6"	4"	20"	12320
813	54"	60"	48"	40"	20.0	661	7200	10800	6"	4"	20"	13170
814	60"	60"	54"	43"	22.5	726	7700	11400	8"	6"	22"	14120
815	60"	60"	54"	43"	22.5	763	8250	12375	8"	6"	22"	14340
816	60"	66"	54"	43"	24.5	826	9000	13500	8"	6"	22"	15340
818	60"	66"	60"	46"	24.5	900	10000	15000	8"	6"	22"	16040
820	66"	66"	60"	46"	27.5	1027	11500	17250	8"	6"	26"	19190
823	66"	72"	60"	46"	30.0	1158	13000	19500	8"	6"	26"	20750
825	66"	72"	60"	46"	30.0	1255	15000	22500	8"	6"	26"	21860
827	72"	72"	66"	49"	33.0	1349	16500	24750	8"	6"	30"	23920
830	72"	78"	66"	49"	35.75	1501	18000	27000	8"	6"	30"	25340
833	78"	72"	72"	55"	36.0	1644	20000	30000	10"	6"	32"	27840
837	78"	84"	72"	55"	42.0	1877	22500	33750	10"	6"	32"	30730
840	78"	84"	72"	55"	42.0	2017	25000	37500	10"	6"	32"	32640

Ames Firebox Heating Boiler with Downdraft Furnace

No. of Size	Diam. Shell	Length Furnace	Width Furnace	Height Furnace Above Lower Grates	Length Grates	Grate Area Sq. Ft. A.S.N.E. Rat'g	Sq. Ft. Heating Surface	Sq. Ft. Cap. Steam Rad.	Sq. Ft. Cap. Water Rad.	Size Steam Outlet	Size Return	Diam. Chimney	Weight in Lbs. Boiler Complete
905	42"	66"	36"	41"	42"	13.13	258	2625	3938	5"	3"	14"	7880
908	48"	66"	42"	44"	42"	15.31	408	4100	6150	6"	4"	16"	10230
910	54"	74"	48"	47"	48"	20.00	597	5200	7800	6"	4"	20"	12010
912	54"	78"	48"	47"	54"	22.50	622	6100	9150	6"	4"	20"	13170
913	54"	84"	48"	47"	60"	25.00	718	6500	9750	6"	4"	20"	13870
914	60"	84"	54"	50"	60"	28.12	765	7500	11250	8"	6"	22"	15480
915	60"	85"	54"	50"	60"	28.12	831	8200	12300	8"	6"	22"	15880
916	60"	90"	54"	50"	66"	30.94	901	9000	13500	8"	6"	22"	17160
918	60"	92"	54"	50"	66"	30.94	1009	10250	15375	8"	6"	22"	17770
920	60"	96"	54"	50"	72"	33.75	1154	12000	18000	8"	6"	22"	19230
923	66"	97"	60"	53"	78"	37.50	1286	13500	20250	8"	6"	26"	23040
925	66"	104"	60"	53"	84"	43.75	1500	16000	24000	8"	6"	26"	24300
927	66"	108"	60"	53"	84"	44.69	1662	18000	27000	10"	6"	30"	27160
930	72"	102"	66"	56"	78"	44.69	1810	20000	30000	10"	6"	30"	27740
933	72"	104"	66"	56"	88"	50.39		23500	35250	10"	6"	30"	30230

Continental Heater Corporation

Home Office and Factory

Dunkirk, N. Y.

Manufacturers of Boilers and Radiators

CONTINENTAL-BERNHARD WATER TUBE BOILER

Lowest in Stature—Highest in Efficiency

A highly efficient boiler which sends dry steam to the mains and which has the added advantage of a very low water line.

There is good circulation of water in each individual section and throughout entire boiler.

Highly favored for vapor installations because of low, steady water line.

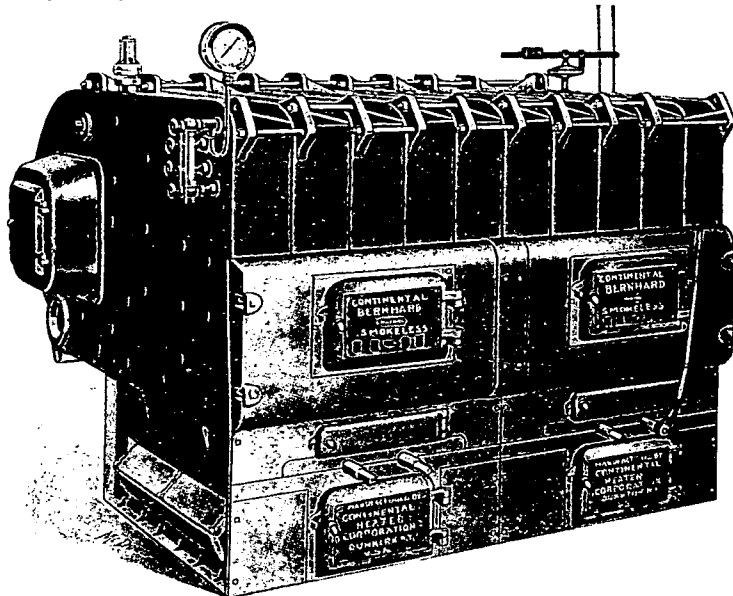
Firing short way of the grate makes possible the easy utilization of entire grate surface.

The fire rises to crown sheet completely enveloping the water tubes, then passing to rear combustion chamber, it travels to one end of boiler, enters rear flue and travels full length of boiler to smoke exit.

The flue ways because of their design are practically self-cleaning.

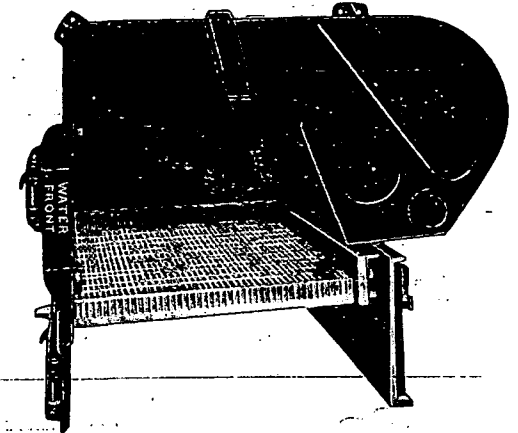
Smoke exit may be taken from either end or rear.

Also built in double series with separate fire boxes which may be used independently.



Single Grate Up-Draft Boiler—Smokeless and Regular Type
Anthracite and Bituminous can be satisfactorily used in both types.

The smokeless type has an air jet for each intermediate section. These jets introduce intensely heated air, which becomes thoroughly mixed with the gases in the combustion chamber, resulting in the elimination of objectionable smoke.



Interior View—Showing location of air jets

Boiler Data—Smokeless and Regular Type

Number	Steam Rating	Water Rating	Grate Area	Flow & Return 2 Each	Front Length of Boiler	Extreme Overall Depth	Chimney Area Inches	Chimney Height Feet
20 SERIES WATER LINE 38" HEIGHT OF FLOW 43"								
25	700	1150	3.88	3"	35"	39"	8x12	35
26	900	1500	4.85	3"	42"	39"	8x12	35
27	1100	1850	5.82	3"	49"	39"	8x12	40
28	1300	2200	6.80	3"	56"	39"	8x12	40
30 SERIES WATER LINE 43" HEIGHT OF FLOW 48"								
35	1200	2000	5.83	4"	35"	54"	12x12	40
36	1600	2650	7.29	4"	42"	54"	12x12	40
37	2000	3300	8.75	4"	49"	54"	12x12	40
38	2400	4000	10.21	4"	56"	54"	12x12	40
39	2800	4650	11.67	4"	63"	54"	12x16	40
310	3200	5300	13.13	4"	70"	54"	12x16	45
311	3600	6000	14.59	4"	77"	54"	16x16	45
312	4000	6650	16.05	4"	84"	54"	16x16	45
40 SERIES WATER LINE 47" HEIGHT OF FLOW 54"								
46	2500	4150	9.72	5"	42"	78"	12x16	50
47	3200	5300	11.66	5"	49"	78"	12x16	50
48	3900	6450	13.60	5"	56"	78"	16x16	50
49	4600	7600	15.54	5"	63"	78"	16x20	55
410	5300	8750	17.48	5"	70"	78"	16x20	55
411	6000	9900	19.43	5"	77"	78"	20x20	55
412	6700	11100	21.35	5"	84"	78"	20x20	60
413	7400	12250	23.32	5"	91"	78"	24x24	65
414	8100	13400	25.27	5"	98"	78"	24x24	65
415	8800	14550	27.22	5"	105"	78"	24x28	65
416	9500	15700	29.17	5"	112"	78"	28x28	70
417	10200	16850	30.12	5"	119"	78"	28x28	70
418	10900	18000	32.07	5"	126"	78"	28x32	70

* Also one 4" flow. ** Also two 4" flows.

Cost of these specially designed water tube boilers will compare favorably with cost of the ordinary type.

Double series boilers 2,600 to 22,300 square feet steam capacity.

Small square sectional boilers 190 to 825 square feet steam—340 to 1,400 square feet water.

J. F. DAVIS & SONS COMPANY

1122-1123-1124 Harris Trust Bldg.

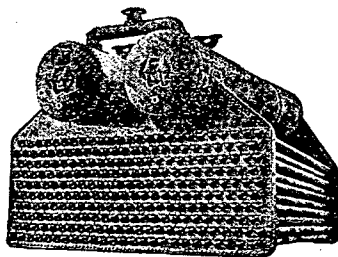
111 W. Monroe St.

CHICAGO, ILL.

LIST OF AGENTS:

BLISS & LYON
702 Balboa Bldg., San Francisco, Cal.
MECHANICAL SERVICE COMPANY
Metropolitan Life Bldg., Minneapolis, Minn.
MECHANICAL EQUIPMENT SALES CO.
Metropolitan Block
Milwaukee, Wisconsin

MR. B. C. MOSS
707 Mutual Bldg., Kansas City, Mo.
MOUNTAIN STATES MACHINERY CO.
U. S. National Bank Bldg., Denver, Colorado
MR. P. W. SCHUBERT
220 Railway Exchange, Seattle, Wash.
MR. W. E. HVLAND
728 World-Herald Bldg., Omaha, Nebraska



This Company designs and builds:

Standard Longitudinal Drum Water Tube Boilers from 100 to 1500 Horse Power, and all pressures from 175 pounds to 350 pounds.

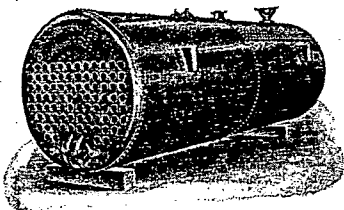
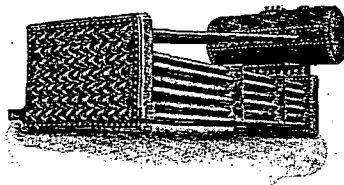
Standard Cross Drum Water Tube Boilers from 75 to 1000 horse power and from 175 pounds to 300 pounds pressure.

Medium pressure Cross Drum Water Tube Boilers for heating or power, from 50 to 300 horse power and for 125 pounds pressure.

Return Tubular boilers from 54 inches in diameter to 84 inches in diameter and for 125 and 150 pounds pressure.

All boilers will be built on a factor of safety of five in accordance with the requirements of the A. S. M. E. Code, and represent the best judgment of years of experience in the design of these types.

The Company is prepared by experience and equipment to design and execute the most intricate and exacting work in steel plate construction, including Stacks, Smoke Flues, Storage Tanks for Oil and Water, Pressure Tanks and Coal Bunkers.



Keystone Boiler & Foundry Co.

Landisville, Pa.

"Keystone" Spiral Water Tube Boilers—welded and riveted.

This type of boiler has been built here by us for more than 30 years and the first boilers are still in use.

Heating surface extraordinarily effective, even if boiler is not cleaned.

Rocking grates, all connections on outside of base.

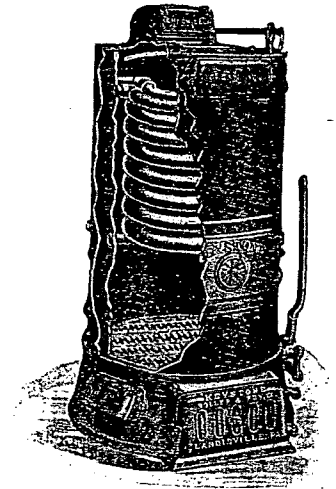
Supply openings out of top of shell.

No straight or rigid fire surface. Not affected by expansion or contraction even when overheated.

Complete catalogue giving all dimensions, etc., sent on application; also list of buildings heated by Keystone Boilers.

Trimings, for Steam: Safety Valve, Automatic Damper Regulator, Draw-off Cock, Water Column with steam gauge and syphon, water gauge and two gauge cocks attached.

For Hot Water: Draw-off Cock and Thermometer.



Dimensions and Price Lists of Boilers
Steam and Hot Water, Welded or Riveted

No. Boiler	Diameter Grate	Smoke Pipe, Near Base, Oval Ends	Tappings, Two Re- mains, Two 4	Height Comp.	Guaranteed Rating, Water	Price, Water	Guaranteed Rating, Steam	Price, Steam
18	13 1/2"	5 1/2"x8"	2"	55"	280	\$ 120.00	175	\$ 130.00
21	16 1/2"	5 1/2"x9 1/2"	2"	60"	460	160.00	300	180.00
25	19 1/2"	5 1/2"x9 1/2"	2 1/2"	63"	620	200.00	400	220.00
28	22"	6"x12 1/2"	2 1/2"	65 1/2"	800	240.00	525	260.00
32	25"	6"x12 1/2"	3"	66"	1025	300.00	675	320.00
35	28"	6"x12 1/2"	3"	66"	1350	350.00	875	370.00
38	31"	8"x15"	3"	69"	1640	410.00	1075	430.00
42	35"	8"x15"	4"	75"	2500	540.00	1600	560.00
42-6	35"	8"x15"	4"	81"	2800	590.00	1800	600.00
48	41"	7 3/4"x22 1/2"	4"	76"	3350	660.00	2175	680.00
48-6	41"	7 3/4"x22 1/2"	4"	82"	4100	720.00	2700	740.00
48-12	41"	7 3/4"x22 1/2"	4"	82"	4600	760.00	3000	780.00
Twin 42	2-35"	2-8"x15"	4"	75"	5000	1080.00	3200	1120.00
Twin 42-6	2-35"	2-8"x15"	4"	81"	5600	1180.00	3600	1220.00
Twin 48	2-41"	2-7 3/4"x22 1/2"	4"	76"	6700	1320.00	4350	1360.00
Twin 48-6	2-41"	2-7 3/4"x22 1/2"	4"	82"	8200	1440.00	5400	1480.00
Twin 48-12	2-41"	2-7 3/4"x22 1/2"	4"	86"	9200	1520.00	6000	1560.00

Above prices subject to discount.

The ratings shown are based on a firing period of 8 hours.

Can furnish Brass and Copper Coils at an additional cost. Special size Boilers with greater capacities than those listed built to order. The larger sized Boilers can be built in sections, where cellar openings will not admit standard sizes.

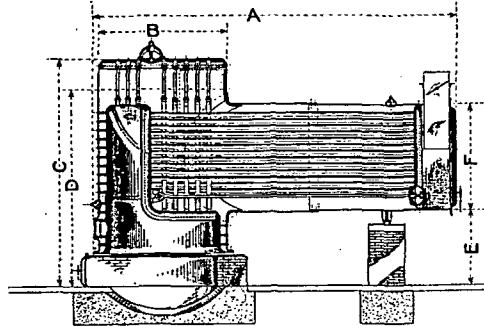
Fitzgibbons Boiler Co., Inc.

Established 1886

Works: Oswego, N. Y.

General Offices: 47 West 42nd Street, New York City

Fitzgibbons Power and Heating Boilers, 30 to 350 H.P., for 150, 125, 100 and 15 lbs. working pressure. Built to A.S.M.E. Boiler Code. Adapted to Bituminous, Semi-Bituminous, Anthracite and Oil Fuel. Compact. Accessible. Do not require Brick Setting



150 and 125 Lbs. Pressure

Number	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
Horse Power	30	40	50	60	70	80	90	100	125	150	175	200	225	250	300	325	350
A—ft. in. overall	10-3	11-5	12-5	12-6	13-8	13-9	14-10	15-8	16-9	17-1	18-1	18-7	19-9	20-6	22-0	23-9	24-9
B—ft. in.	3-6	3-11	4-3	4-8	4-11	5-1	5-3	5-5	5-9	6-3	6-7	6-11	7-1	7-3	7-9	7-10	7-11
C—ft. in.	7-9	8-1	8-8	9-2	9-5	10-0	10-1	10-4	10-10	11-6*	11-9	12-3	12-3	12-10	17-10	17-10	17-10
D—ft. in. W. L.	6-4	6-6	7-1	7-5	7-8	8-2	8-2	8-4	8-10	9-6*	9-7	10-2	10-2	10-10	These boilers set		
E—ft. in.	2-10	2-10	2-10	2-10	2-10	3-1	3-1	3-1	3-1	3-3	3-7*	3-11	3-9	4-1	upon brick fur-		
F—ft. in.	2-10	3-1	3-8	4-0	4-2	4-6	4-6	4-8	5-0	5-4	5-9	5-11	6-0	6-2	naces shown on op-		
															posite page		

100 Lbs. Pressure

Number	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	21	21
Horse power	30	40	50	60	70	80	90	100	125	150	175	200	225	250	300	325	350
A—ft. in. overall	9-8	10-6	11-5	11-5	12-4	12-7	13-6	14-2	15-0	15-5	16-1	16-7	17-5	18-3	22-0	23-9	24-9
B—ft. in.	3-6	3-11	4-3	4-8	4-11	5-1	5-3	5-5	5-9	6-3	6-7	6-11	7-1	7-3	7-9	7-10	7-11
C—ft. in.	7-9	8-1	8-8	9-2	9-5	10-0	10-1	10-4	10-10	11-6*	11-9	12-3	12-3	12-10	17-10	17-10	17-10
D—ft. in. W. L.	6-4	6-6	7-1	7-5	7-8	8-2	8-2	8-4	8-10	9-6*	9-7	10-2	10-2	10-10	These boilers set		
E—ft. in.	2-10	2-10	2-10	2-10	2-10	3-1	3-1	3-1	3-3	3-7*	3-11	3-9	3-9	4-1	upon brick fur-		
F—ft. in.	2-10	3-1	3-8	4-0	4-2	4-6	4-6	4-8	5-0	5-4	5-9	5-11	6-0	6-2	naces shown on op-		
															posite page		

NOTE—The height of above boilers and water lines includes a circular brick base and ash pit, which is 14 in. for 150 H.P.; 16 in. for 175 H.P.; 18 in. for 200 and 225 H.P.; and 20 in. for 250 H.P. Boilers above 250 H.P. set on brick furnace.

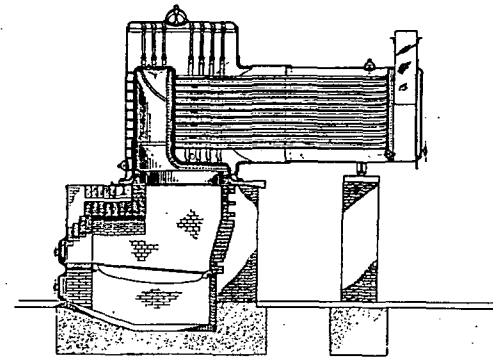
15 Lbs. Pressure—For Heating

Number	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38
Horse power	30	40	50	60	70	80	90	100	125	150	175	200	225	250	300	325	350
Steam Radia- tion, sq. ft.	3200	4300	5400	6400	7500	8500	9500	11000	13500	16500	19000	22000	25000	28000			
A—ft. in. over li	9-8	10-6	11-5	11-5	12-4	12-7	13-6	14-2	15-0	15-5	16-1	16-7	17-5	18-3	22-0	23-9	24-9
B—ft. in.	3-6	3-11	4-3	4-8	4-11	5-1	5-3	5-5	5-9	6-3	6-7	6-11	7-1	7-3	7-9	7-10	7-11
C—ft. in.	7-3	7-6	8-0	8-5	8-10	9-5	9-5	9-7	10-1	10-10	11-9	11-8	11-11	12-4	These boilers		
D—ft. in. W. L.	6-4	6-6	7-1	7-5	7-8	8-2	8-2	8-4	8-10	9-6	10-1	10-3	10-8	10-8	set upon brick		
E—ft. in.	2-10	2-10	2-10	2-10	2-10	3-1	3-1	3-1	3-3	3-7	3-11	3-9	3-9	4-1	furnaces		
F—ft. in.	2-10	3-1	3-8	4-0	4-2	4-6	4-6	4-8	5-0	5-4	5-9	5-11	6-0	6-2	shown on op-		
															posite page		

NOTE—The height of above boilers and water lines includes a circular brick base and ash pit which is 16 in. for No. 32; 18 in. for Nos. 33 and 34; and 20 in. for No. 35. No brick base or pier on boilers No. 31 and smaller.

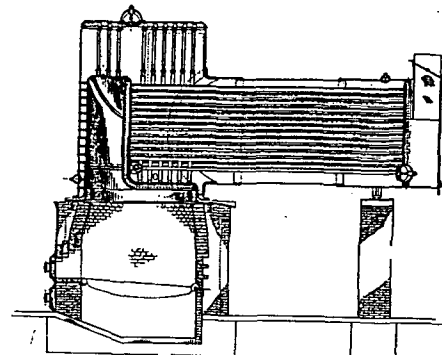
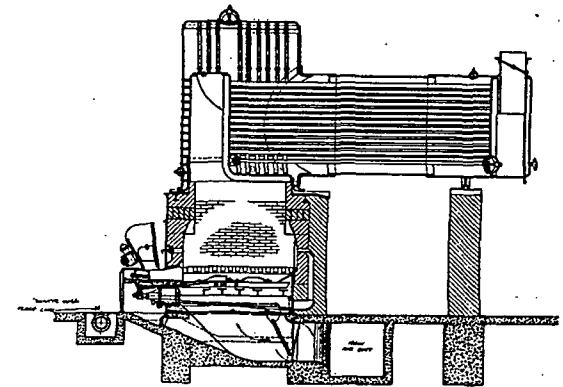
The horsepower rating listed is the guaranteed horsepower the boiler is capable of developing when burning a good grade of semi-bituminous coal with proper draft.

The Steam Radiation is the equivalent total direct radiation including all exposed piping which the boiler will readily carry when burning a medium size anthracite coal with proper draft. This rating is approximately 20 per cent. less than the horsepower equivalent, thereby allowing ample reserve capacity in the boiler to meet adverse conditions arising in operation.



Sectional view of Fitzgibbons Boiler with Dutch Oven for sawdust, shavings, wood, refuse, small size anthracite and other low grade fuels. Adaptable to oil and powdered coal burning equipment and wasteheat furnaces.

Sectional view of Fitzgibbons Boiler with underfeed stoker. Adaptable as well to inclined and chain grate stokers.



Sectional view of 300 H. P. Fitzgibbons Boiler with circular extension furnace for medium size anthracite, bituminous and oil fuels.

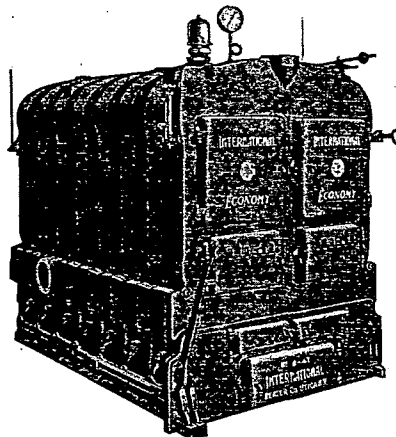
INTERNATIONAL HEATER COMPANY

Utica, N. Y.

BRANCHES:

CHICAGO NEW YORK NASHUA, N. H. CLEVELAND, O.
1933-35 Wentworth Ave. Broadway & 57th St. 369 Main St. 1441 Davenport Ave., N. E.

Manufacturers of Heating Apparatus



No. 8-47 International Economy Steam Boiler

INTERNATIONAL ECONOMY BOILERS

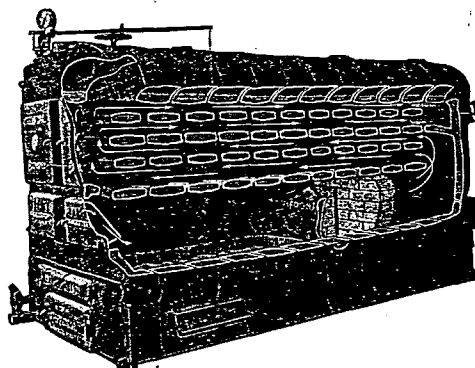
On the following pages we present condensed data on the International Economy Sectional Boilers.

Both the Regular and the Smokeless patterns have the following distinctive features in common: They will absolutely deliver dry steam to the system without the use of a special header. The grate bars have their connections entirely outside the boiler and shaking attachment may be placed on either side. They have a low water line. The water gauge is tapped directly into the section. Large doors give easy access for cleaning from the front. They have a high evaporative power and they are conservatively rated from actual tests according to the A. S. H. & V. E. Code.

In the regular pattern boilers provision is made so that tongues of flame pass up between the sections of the crown sheet and thoroughly ignite the gases in the mixing chamber, as the lower row of flues is called. This is the well known carburetor principle which has always been a feature of Economy Boilers.

The International Economy Smokeless Boiler

is an up-draft boiler. It is built on the Kent Wing Wall principle so that the smokeless feature is entirely outside of the fire box and practically independent of the fireman. It has no special grates or arches in the fire box, holds several hours' supply of coal and requires the least possible attention. Excess air is always under control,—an important feature that promotes fuel economy.



Cutaway View of No. 130-47 Smokeless Boiler

INTERNATIONAL HEATER COMPANY

STANDARD SPECIFICATION FOR SMOKELESS BOILER INSTALLATION

Low pressure up-draft smokeless steam boilers, of the push nipple sectional cast iron type, shall be furnished complete; boiler to be equipped with an all metal automatic damper regulator, water gauge, try cocks, pressure gauge, safety valve, firing and cleaning tools, etc.

In burning bituminous coal of high volatile content of over 30 per cent, the smoke density produced by the boilers shall come within the regular smoke ordinance requirements of not to exceed 10 per cent. in density per hour according to Ringlemann's standard. To meet this smoke requirement special exacting methods of firing and special expert skill shall not be required of the fireman in charge, and the excess air required over the fire shall be under convenient control of the fireman.

Boiler, when operating under standard code conditions, shall be capable of producing at least four thousand pounds of dry steam per hour, an equivalent of sixteen thousand square feet of direct steam radiation. The rated capacities of the boiler shall have been determined according to the Testing Code of the A. S. H. & V. E. and the soft coal ratings shall not exceed that of the hard coal ratings for the same size boiler of similar overall dimensions.

To minimize the frequency of firing fuel, fire box shall contain ample fuel to develop the rated capacity of the boiler for at least two and one-half to three hours, and the depth of the fuel on the grates shall in no place be less than sixteen inches, with the top of the fuel bed at least four to six inches below the lower projection of the crown sheet. A fuel capacity of one ton is ample in the largest size boilers and the length of the fire box shall not exceed 80 inches. The fuel capacity and evaporative power of each boiler at the rated capacity given shall be stated in the bid.

The height of the water line shall not exceed sixty-four inches and shall be so

located that all heating surfaces exposed to the fire and hot flue gases shall be backed up by water and not steam. The boiler shall be capable of delivering dry steam at the boiler outlet when subjected to overloads of 50 to 100 per cent. for short periods when forced to the limit in cold spells. Boiler construction features such as accessibility for keeping the heating surfaces clean, the absence of soot pockets, the direction of the flue travel and its effect on the positive water circulation within the boiler sections, dry steam conditions, quality of heating surface, etc., shall be considered before any boiler is accepted as meeting the requirements for this particular installation.

An ashpit twelve inches deep of good concrete or hard brick construction shall be placed under the entire grate of the boiler. In mounting the boiler, as each section is pulled up into position it shall be thoroughly cemented with boiler cement (not regular asbestos covering) or joints packed with asbestos rope to prevent short circuiting of the hot gases within the boiler. After the boiler is mounted and the push nipples made water tight under 15 pounds water pressure, the space between each section around the outer edge shall be thoroughly cemented with boiler cement (not asbestos covering), also along base of sections and around smoke box, to prevent air leakage into the fire or flue travel, and the nuts on the tie rods shall be loosened up to allow for expansion of the sections. No rigid flow or return headers shall be allowed. During temporary heat none of the condensed water shall be permitted to return to the boiler until all oil, grease, sand, etc., shall be eliminated from the system. The boiler, piping and radiation shall be free from oil, grease and foreign matter before the plant is accepted. A durable damper with quadrant adjustment shall be placed in the smoke pipe from boiler and another in the main breeching near the chimney.

INTERNATIONAL ECONOMY

Reg. U. S. Pat. Off.

SMOKELESS BOILERS

STEAM				WATER				TAPPINGS				WATER				Chim. Dim.				Inside Dim. of			
Number	Rating	Number	Rating	Surface of Fuel Bed	Length of Boiler	Supply	Return	Supply	Return	Supply	Return	Chim. Dim.	Height	Chim. Dim.	Height	Chim. Dim.	Height	Chim. Dim.	Height	Inside Dim. of	Height	Inside Dim. of	Height
62-26	2000	26-62	3300	26x28	53	2-3/4	2-3/4	2-3/4	2-3/4	12x12	50	25 1/4 x 32											
71-26	2100	26-71	3475	26x32	57 1/2	3-3/8	2-3/4	3-3/8	4-3/8	12x12	50	25 1/4 x 35 1/2											
72-26	2300	26-72	3800	26x36	61	3-3/8	2-3/4	3-3/8	4-3/8	12x16	50	25 1/4 x 40											
81-26	2400	26-81	3975	26x40	65 1/2	3-3/8	2-3/4	3-3/8	4-3/8	12x16	55	25 1/4 x 43 1/2											
82-26	2600	26-82	4300	26x44	69	3-3/8	2-3/4	3-3/8	4-3/8	12x16	60	25 1/4 x 48											
71-31	2700	31-71	4450	31x28	57 1/2	2-4	2-4	2-4	2-4	12x16	55	30 1/4 x 32											
80-31	2850	31-80	4700	31x32	61	2-4	2-4	2-4	2-4	12x16	55	30 1/4 x 35 1/2											
81-31	3100	31-81	5100	31x36	65 1/2	2-4	2-4	2-4	2-4	16x16	50	30 1/4 x 40											
90-31	3250	31-90	5350	31x40	69	2-4	2-4	2-4	2-4	16x16	50	30 1/4 x 43 1/2											
91-31	3500	31-91	5750	31x44	73 1/2	2-4	2-4	2-4	2-4	16x16	50	30 1/4 x 48											
100-31	3650	31-100	6000	31x48	77	2-4	2-4	2-4	2-4	16x16	55	30 1/4 x 51 1/2											
101-31	3900	31-101	6400	31x52	81 1/2	2-4	2-4	2-4	2-4	16x16	55	30 1/4 x 56											
110-31	4050	31-110	6650	31x56	85	2-4	2-4	2-4	2-4	16x16	60	30 1/4 x 59 1/2											
80-38	4150	38-80	6850	38x32	61	2-5	2-5	2-5	2-5	20x20	55	36 1/4 x 35 1/2											
81-38	4450	38-81	7350	38x36	65 1/2	2-5	2-5	2-5	2-5	20x20	55	36 1/4 x 40											
90-38	4700	38-90	7750	38x40	69	2-5	2-5	2-5	2-5	20x20	60	36 1/4 x 43 1/2											
91-38	5000	38-91	8250	38x44	73 1/2	2-5	2-5	2-5	2-5	20x20	65	36 1/4 x 48											
100-38	5250	38-100	8650	38x48	77	2-5	2-5	2-5	2-5	20x20	70	36 1/4 x 51 1/2											
101-38	5550	38-101	9150	38x52	81 1/2	2-5	2-5	2-5	2-5	24x24	60	36 1/4 x 56											
110-38	5800	38-110	9550	38x56	85	2-5	2-5	2-5	2-5	24x24	60	36 1/4 x 59 1/2											
111-38	6100	38-111	9950	38x60	89 1/2	2-5	2-5	2-5	2-5	24x24	60	36 1/4 x 64											
120-38	6350	38-120	10450	38x64	93	2-5	2-5	2-5	2-5	24x24	65	36 1/4 x 67 1/2											
71-47	6900	47-71	11500	47x40	69	2-6	2-6	2-6	2-6	24x24	65	48 1/4 x 44											
72-47	7500	47-72	12500	47x45	75	2-6	2-6	2-6	2-6	24x24	65	48 1/4 x 50											
81-47	7900	47-81	13150	47x50	79	2-6	2-6	2-6	2-6	24x24	65	48 1/4 x 54											
82-47	8500	47-82	14150	47x55	85	2-6	2-6	2-6	2-6	24x28	65	48 1/4 x 60											
91-47	8900	47-91	14800	47x55	89	2-6	2-6	2-6	2-6	24x28	65	48 1/4 x 60											
100-47	9300	47-100	15500	47x60	94	2-6	2-6	2-6	2-6	24x28	65	48 1/4 x 64											
101-47	9900	47-101	16500	47x60	99	2-6	2-6	2-6	2-6	28x28	65	48 1/4 x 64											
110-47	10300	47-110	17150	47x60	104	2-6	2-6	2-6	2-6	28x28	65	48 1/4 x 64											
111-47	10900	47-111	18150	47x65	109	2-6	2-6	2-6	2-6	28x28	65	48 1/4 x 70											
112-47	11500	47-112	19150	47x65	114	2-6	2-6	2-6	2-6	28x28	65	48 1/4 x 70											
121-47	11900	47-121	19800	47x65	119	2-6	2-6	2-6	2-6	30x30	65	48 1/4 x 74											
130-47	12300	47-130	20450	47x70	124	2-6	2-6	2-6	2-6	30x30	65	48 1/4 x 74											
131-47	12900	47-131	21450	47x70	129	2-6	2-6	2-6	2-6	30x30	70	48 1/4 x 74											
140-47	13300	47-140	22100	47x70	134	2-6	2-6	2-6	2-6	30x30	70	48 1/4 x 74											
141-47	13900	47-141	23100	47x75	139	2-6	2-6	2-6	2-6	30x30	70	48 1/4 x 80											
142-47	14500	47-142	24100	47x75	144	2-6	2-6	2-6	2-6	30x30	75	48 1/4 x 80											
151-47	14900	47-151	24750	47x75	149	2-6	2-6	2-6	2-6	30x30	75	48 1/4 x 80											

	STEAM				WATER			
SERIES	26	31	38	47	26	31	38	47
Height of Water Line.....	47	50	54	59				
Height to Supply Outlets.....	58½	62¼	67¾	73	55	59	66	73
Add to height for Trimmings.....	11	11	11	12				
Add to length of Boiler for Smoke Box.....	7½"	7¾"	8¼"	8¾"	7½"	7¾"	8¼"	8¾"
Width of Boiler.....					36	42	48	59
Width of Boiler includ. Trimmings.....	40	45	53	61				
Height from floor to Center of Return Tappings.....	20	20½	21	21½	20	20½	21	21½
Height of Fire Box to Crown.....	22	24	26	26	22	24	26	26
Height, Grate to Middle of Feed Door.....	16	18	20	20	16	18	20	20
Size of Smoke Flue.....	10	12	16	20	10	12	16	20
				(2)				(2)
Size of Feed Door.....	9x17	9x17	11x21	10x17	9x17	9x17	11x21	10x17

Trimmings as listed below are sent with each Steam Boiler without extra charge.
 One 8-inch Economy Deegan Regulator with lever, weight, chains and pulleys.
 One Water Gauge complete with glass and brass rods.
 Two Brass Compression Cocks.
 One Steam Gauge with Pigtail Syphon.
 One Safety Valve.
 Outlets for Safety Valves are tapped in accordance with the A. S. M. E. Code.
 No Trimmings are sent with Water Boilers.
 Fire Tools. With every Steam and Water Boiler there is sent free a Brush, Poker and Scraper.

SPECIAL CATALOG WILL BE SENT ON APPLICATION

INTERNATIONAL ECONOMY SECTIONAL BOILERS

STEAM

Number	Rating	Coal Capacity Pounds	Evaporative Power	Surface of Fuel Bed Inches	Length of Boiler Inches	Inside Dim. of Ashpit Inches	TAPPINGS**	
							Supply	Return
35-19	700	195	9.6	19x20	25 1/2	22x24	2-3"	2-3"
4-19	825	225	9.6	19x24	28	22x27 1/2	2-3"	2-3"
45-19	975	265	9.6	19x28	33 1/2	22x32	2-3"	2-3"
5-19	1100	295	9.6	19x32	37	22x35 1/2	2-3"	2-3"
4-26	1000	290	9.3	26x24	29	25 1/4 x 27 1/2	2-3 1/2"	2-3 1/2"
45-26	1200	340	9.3	26x28	33 1/2	25 1/4 x 32	2-3 1/2"	2-3 1/2"
5-26	1300	375	9.3	26x32	37	25 1/4 x 35 1/2	2-3 1/2"	2-3 1/2"
55-26	1500	425	9.3	26x36	41 1/2	25 1/4 x 40	2-3 1/2"	2-3 1/2"
6-26	1600	460	9.3	26x40	45	25 1/4 x 43 1/2	2-3 1/2"	2-3 1/2"
5-31	1650	480	9.3	31x32	37	30 1/4 x 35 1/2	2-4"	2-4"
55-31	1900	545	9.3	31x36	41 1/2	30 1/4 x 40	2-4"	2-4"
6-31	2050	590	9.3	31x40	45	30 1/4 x 43 1/2	2-4"	2-4"
65-31	2300	645	9.3	31x44	49 1/2	30 1/4 x 48	2-4"	2-4"
7-31	2450	705	9.3	31x48	53	30 1/4 x 51 1/2	2-4"	2-4"
75-31	2700	770	9.3	31x52	57 1/2	30 1/4 x 56	2-4"	2-4"
8-31	2850	825	9.3	31x56	61	30 1/4 x 59 1/2	2-4"	2-4"
85-31	3100	890	9.3	31x60	65 1/2	30 1/4 x 64	2-4"	2-4"
5-38	2500	685	9.75	38x32	37	36 1/4 x 35 1/2	2-5"	2-5"
55-38	2800	770	9.75	38x36	41 1/2	36 1/4 x 40	2-5"	2-5"
6-38	3050	835	9.75	38x40	45	36 1/4 x 43 1/2	2-5"	2-5"
65-38	3350	920	9.75	38x44	49 1/2	36 1/4 x 48	2-5"	2-5"
7-38	3600	985	9.75	38x48	53	36 1/4 x 51 1/2	2-5"	2-5"
75-38	3900	1070	9.75	38x52	57 1/2	36 1/4 x 56	2-5"	2-5"
8-38	4150	1135	9.75	38x56	61	36 1/4 x 59 1/2	2-5"	2-5"
85-38	4450	1220	9.75	38x60	65 1/2	36 1/4 x 64	2-5"	2-5"
9-38	4700	1285	9.75	38x64	69	36 1/4 x 67 1/2	2-5"	2-5"
95-38	5000	1370	9.75	38x68	73 1/2	36 1/4 x 72	2-5"	2-5"
10-38	5250	1435	9.75	38x72	77	36 1/4 x 75 1/2	2-5"	2-5"
105-38	5500	1520	9.75	38x76	81 1/2	36 1/4 x 80	2-5"	2-5"
11-38	5800	1585	9.75	38x80	85	36 1/4 x 83 1/2	2-5"	2-5"

INTERNATIONAL ECONOMY SECTIONAL BOILERS

WATER

Number	Rating	Coal Capacity Pounds	Surface of Fuel Bed Inches	Length of Boiler Inches	Inside Dim. of Ashpit Inches	TAPPINGS Supply	Return
19-35	1150	195	19x20	25½	22x24	1-3"	2-3"
19-4	1325	225	19x24	29	22x27½	1-3"	2-3"
19-45	1600	265	19x28	33½	22x32	2-3"	2-3"
19-5	1825	295	19x32	37	22x35½	2-3"	2-3"
26-4	1650	290	26x24	29	25½x27½	2-3½"	2-3½"
26-45	1975	340	26x28	33½	25½x32	2-3½"	2-3½"
26-5	2150	375	26x32	37	25½x35½	2-3½"	2-3½"
26-55	2475	425	26x36	41½	25½x40	2-3½"	2-3½"
26-6	2650	460	26x40	45	25½x43½	2-3½"	2-3½"
31-5	2725	480	31x32	37	30¾x35½	2-4"	2-4"
31-55	3125	545	31x36	41½	30¾x40	2-4"	2-4"
31-6	3375	590	31x40	45	30¾x43½	2-4"	2-4"
31-65	3800	645	31x44	49½	30¾x48	2-4"	2-4"
31-7	4050	705	31x48	53	30¾x51½	3-4"	4-4"
31-75	4450	770	31x52	57½	30¾x56	3-4"	4-4"
31-8	4700	825	31x56	61	30¾x59½	3-4"	4-4"
31-85	5125	890	31x60	65½	30¾x64	3-4"	4-4"
38-5	4125	685	38x32	37	36½x35½	2-5"	2-5"
38-55	4625	770	38x36	41½	36½x40	2-5"	2-5"
38-6	5025	835	38x40	45	36½x43½	2-5"	2-5"
38-65	5525	920	38x44	49½	36½x48	2-5"	2-5"
38-7	5950	985	38x48	53	36½x51½	2-5"	2-5"
38-75	6450	1070	38x52	57½	36½x56	2-5"	2-5"
38-8	6850	1135	38x56	61	36½x59½	3-5"	4-5"
38-85	7350	1220	38x60	65½	36½x64	3-5"	4-5"
38-9	7750	1285	38x64	69	36½x67½	3-5"	4-5"
38-95	8250	1370	38x68	73½	36½x72	3-5"	4-5"
38-10	8650	1435	38x72	77	36½x75½	3-5"	4-5"
38-105	9150	1520	38x76	81½	36½x80	3-5"	4-5"
38-11	9550	1585	38x80	85	36½x83½	3-5"	4-5"

Number	Rating	Surface of Fuel Bed Inches	Length of Boiler Inches	Inside Dim. of Ashpit Inches	TAPPINGS Supply	Return
47-6	8750	47x50	54	48¾x54	2-6"	2-6"
47-65	9750	47x55	59	48¾x60	2-6"	2-6"
47-7	10400	47x60	64	48¾x64	2-6"	2-6"
47-75	11375	47x65	69	48¾x70	2-6"	2-6"
47-8	12050	47x70	74	48¾x74	3-6"	2-6"
47-85	13025	47x75	79	48¾x80	3-6"	2-6"
*B47-9	13700	47x70	84	48¾x74	3-6"	2-6"
47-9	13700	47x80	84	48¾x84	3-6"	2-6"
*B47-95	14700	47x70	89	48¾x74	3-6"	2-6"
47-95	14700	47x85	89	48¾x90	3-6"	2-6"
*B47-10	15350	47x70	94	48¾x74	3-6"	2-6"
47-10	15350	47x90	94	48¾x94	3-6"	2-6"
*B47-105	16350	47x70	99	48¾x74	3-6"	2-6"
47-105	16350	47x95	99	48¾x100	3-6"	2-6"

SERIES	19"	26"	31"	38"	47"
Height to Supply Outlets.....	50"	54"	58½"	65"	72½"
Width of Boiler.....	33"	36"	42"	48"	59"
Add to length of Boiler for Smoke Box.....	6"	7½"	7¾"	8¾"	8¾"
Height from Floor to Center of Return Tappings.....	18"	19"	19½"	19½"	21½"
Height of Fire Box to Crown.....	22"	22"	24"	26"	26"
Height, Grate to Middle of Feed Door.....	16"	16"	18"	20"	20"
Size of Smoke Flue.....	9"	10"	12"	16"	20"
Size of Feed Door.....	9x14"	9x17"	9x17"	11x21" (2)	10x17"

No Trimmings are sent with Water Boilers.

Fire Tools—With every Steam and Water Boiler there is sent free a Brush, Hoe and Slice Bar.

*Sizes marked with a star as regularly shipped have a bridgwall limiting the grate to convenient length for hand firing. Full length grates are shipped only when specified on the order.

SPECIAL CATALOG WILL BE SENT ON APPLICATION

The INTERNATIONAL HEATER COMPANY also manufactures an extensive line of Warm Air Heating Apparatus and will be glad to send catalogs to anyone interested.

L. J. MUELLER FURNACE CO.

Established 1857

207 Reed Street

Milwaukee, Wis.

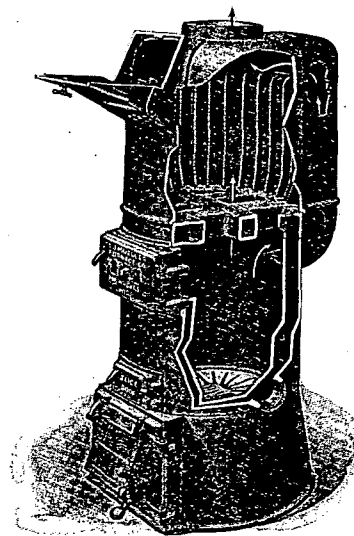
Branches:

New York—132 W. 42nd St.
Chicago—60 E. Lake St.
Detroit—426 Jefferson Ave. E.
St. Paul—158 E. Fifth St.

St. Louis—1409-11 Olive St.
Minneapolis—631 Third Ave. So.
Seattle—410 Occidental Ave.
Portland—609 Panama Bldg.

Makers of

Cast Iron House Heating Boilers, Hot Water Supply Boilers, Garbage Burning Hot Water Supply Boilers, Registers, Ventilators, Grilles, Furnaces, Convectors, Tin and Galvanized Pipe and Fittings.



Note deep combustion chamber, uniform thickness of castings, water-filled garbage grate, large garbage chamber and smoke travel by-pass.

Mueller Garbage Burning Hot Water Supply Boilers are made of cast iron. They are designed and constructed to supply an abundance of hot water for residences, small apartment houses, garages, factories, barber shops, etc., with a small amount of fuel and labor.

They are simple in construction, having but few parts, are quickly and easily erected and offer a sanitary solution of the garbage problem.

The ratings given in the table below are based upon 8 hour firing periods and a temperature rise of 20 degrees per hour using anthracite coal as fuel. Complete list of capacities under different firing periods, details of dimensions, etc., sent upon request.

Mueller Garbage Burning Hot Water Supply Boiler

Sizes and Capacities

Number	Grate Diameter Inches	Nominal Capacity Gals. per Hour	Garbage Capacity Bushels	Number and Size Inlets	Number and Size Outlets
10G	10	168	½	1-1½	2-1½
12G	12	239	1	2-1½	2-1½
14G	14	383	1½	2-2	2-2
16G	16	600	2	2-2	2-2

KEWANEE BOILER COMPANY

Kewanee, Illinois

BRANCHES IN ALL PRINCIPAL CITIES

Steel Heating and Power Boilers, Water Heating Garbage Burners,
Tabasco Heaters, Tanks and Radiators

The Kewanee Boiler Company is approaching its thirty-fifth year in the making of steam heating, fire-box boilers and its product now is recognized as a standard fire-box boiler for low pressure heating purposes.

The Kewanee Smokeless Boiler is designed and constructed to efficiently burn any kind of coal without smoke.

The Straight Draft Boiler has proven to be exceptionally long-lived, as many of the first which were built thirty-five years ago are still in operation and giving good service.

High Fire-Boxes

The height of the fire-box of a boiler is a most important factor, as this affects the completeness of combustion.

Kewanee Boilers have amply high fire-boxes; ample room in the combustion chamber for air—and ample room for the air and heat-giving gases to mix.

Ample Heating Surface

The heating surface of a Kewanee Boiler is that portion of the boiler containing water, against which the fire and gases come in contact. This includes the fire-box of the boiler—which is surrounded by water; the tubes; and, in the case of brick-set boilers, the outside surface of the cylinder or shell, below the water-line. Hence Kewanee Boilers are practically all heating surface.

Kewanee Boilers are built of steel according to the rules of construction adopted by the American Society of Mechanical Engineers, known as the A. S. M. E. Boiler Code.

In addition to the above, we have embodied in the design and construction of these boilers methods which are not only suggested by modern engineering knowledge but also by the results of thirty-five years of practical experience and study—the use of riveted joints, the staying of flat surfaces, arrangement of tubes with relation to each other and to the boiler shells allowing free circulation, together with ample steam space to insure dry steam and a steady water level; also handhole and manhole plates for cleaning and inspection.

Equipment

The list of all brick-set boilers includes Century rocking grates, fire-door and frame, ash-pit front with ash door and draft doors; the necessary soot doors, bearing plates with expansion rollers for supporting boilers upon brick pier at rear of boiler shell. Firing tools include hoe, poker, slice bar and tube scraper.

With all Kewanee Smokeless Boilers, brick-set type, we include extra clean-out doors and frames for side and rear walls.

Back arch bars and manhole shield are furnished with all brick-set boilers. Special fire-brick tile, to fit header, is furnished with all smokeless boilers.

With portable type boilers we furnish all castings for erecting the boilers, including cast-iron ash-pit base for the smaller sizes.

The trimmings for steam boilers are listed separately, consisting of water column with water gauge and compression gauge cocks; steam gauge with syphon and cock; pop safety valve; Syphon Combustion Regulator with lever, weights, pulleys and chains.

No trimmings of any kind are regularly furnished with water boilers.

Sufficient handholes are provided for cleaning purposes and in brick-set boilers 42 inches in diameter and larger, and in portable boilers 54 inches and larger, manholes are included.

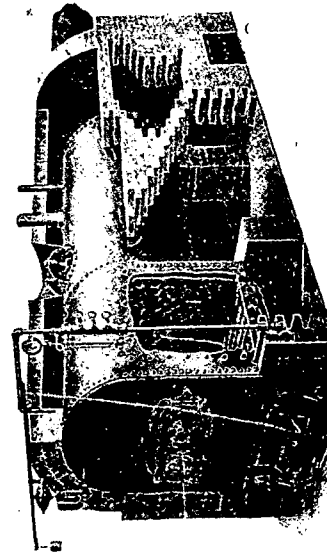
Ratings

The rated capacity of Kewanee Boilers, as printed in this book, is the number of square feet of direct radiating surface or equivalent which the boiler will carry, if sufficient radiation is installed to heat the building to the required temperature.

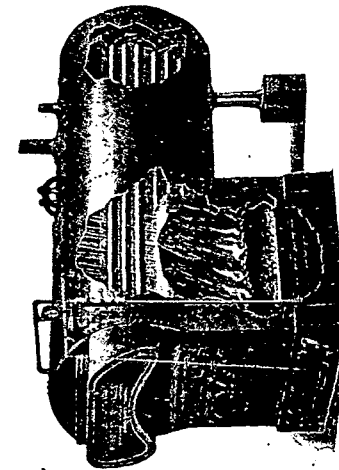
The ratings are based on a standard for steam of two pounds pressure at the boiler, and for water on a mean temperature of 180 degrees Fahrenheit as the water leaves the boiler.

The Century Rocking Grate

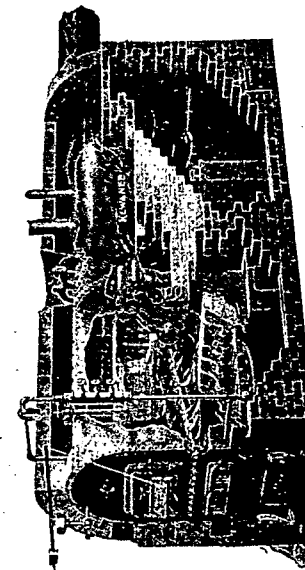
The Century Rocking Grate is furnished with all Kewanee Boilers. It is made of the best selected iron, is heavy, strong and durable, and has an air space of 55 per cent., which renders it highly efficient.



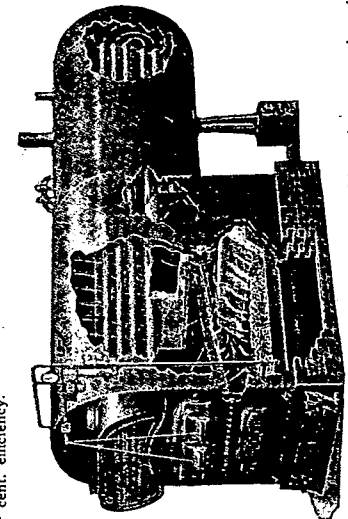
KEWANEE BOILER
—Brick-set—for Heating



KEWANEE BOILER
—Portable—for Heating
Boiler No. 414 (and smaller) made with enlarged cylinder as shown above; ash-pits (as illustrated) furnished with Boiler No. 409 (and smaller).

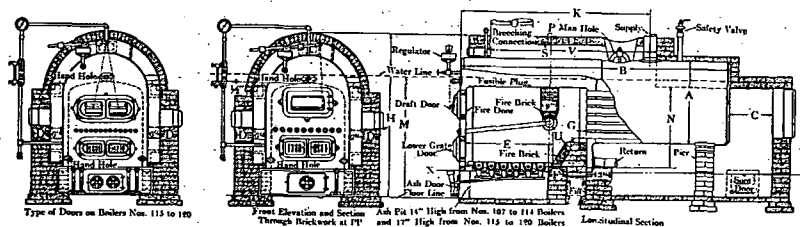


KEWANEE SMOKELESS
BOILER—Brick-set—for Heating
Sectional view, showing arrangement of double grates and long travel of gases. Recent tests of Kewanee Smokeless Boilers, made by a recognized boiler authority, prove that when burning soft coal, under conditions similar to those prevailing in most large buildings, their efficiency ranges from 73 to 81 per cent. The ordinary type heating boiler averages about 60 per cent. efficiency.

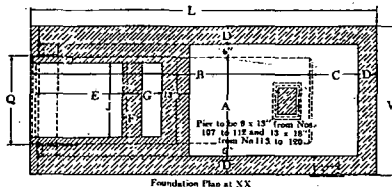
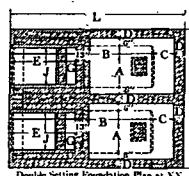
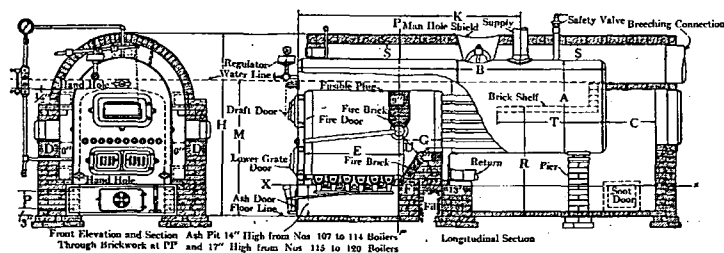


KEWANEE SMOKELESS
BOILER—Portable—for Heating
Boiler No. 315 (and larger) constructed as shown above. Boiler No. 310 (and larger) set on brick foundation as illustrated.

KEWANEE SMOKELESS BOILER—Brick-set—Showing Setting with Stack Connection at Front.

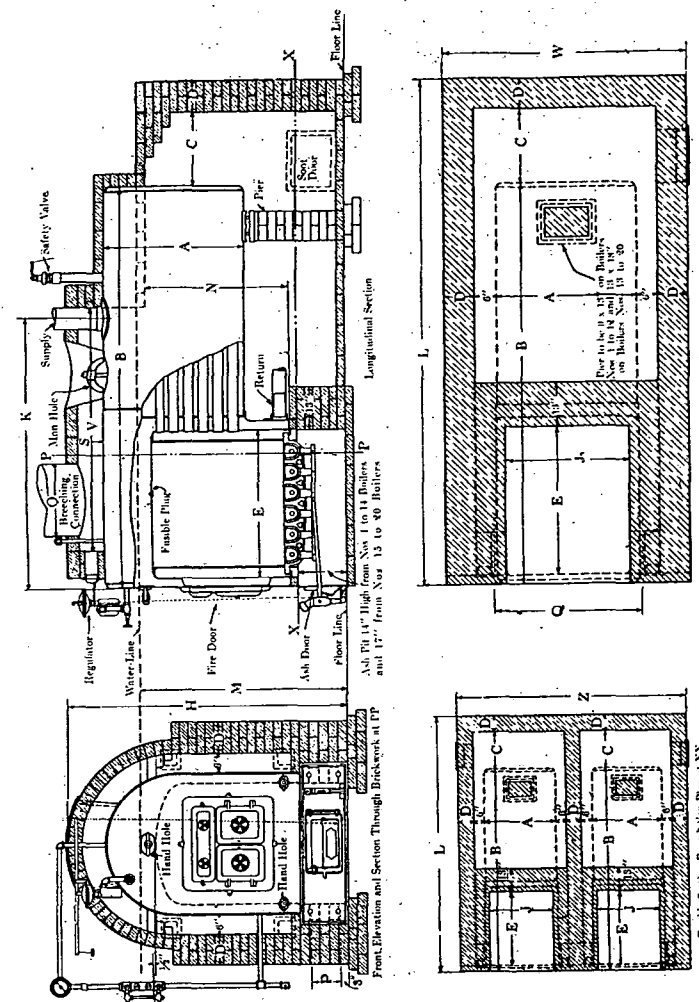


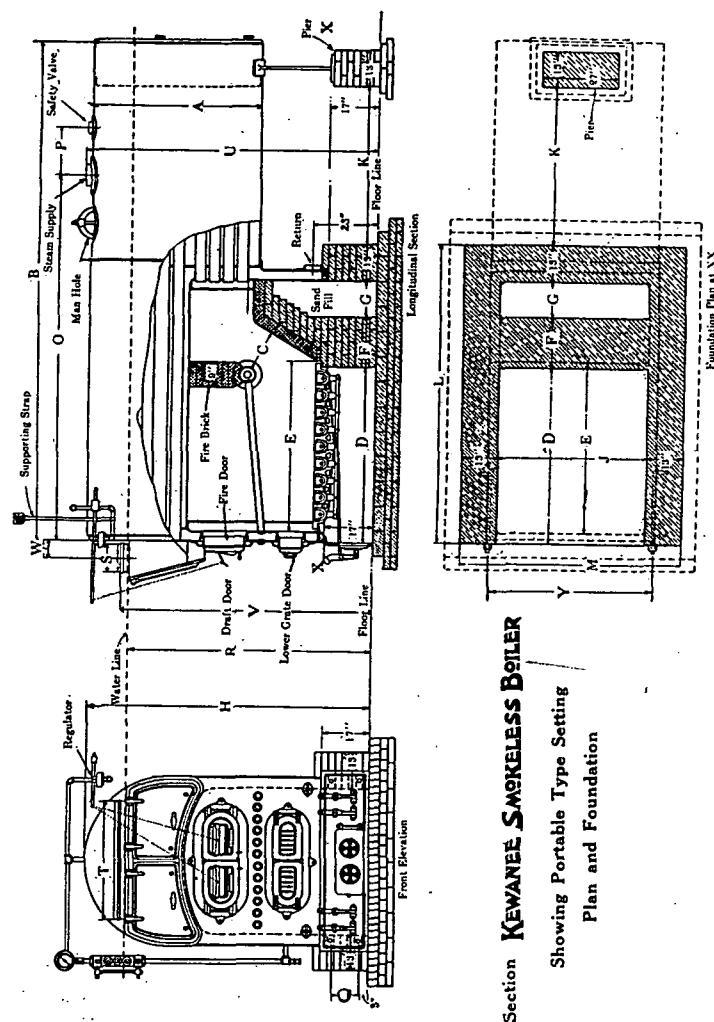
KEWANEE SMOKELESS BOILER Brick-set—Showing setting with Stack Connection at Rear.



Number of Boiler	107	108	109	110	111	112	113	114	115	116	117	118	119	120
A—Diameter Boiler	42	42	42	48	48	48	54	54	60	60	66	66	72	72
B—Length Boiler	12-10	12-10	12-10	12-10	12-10	12-10	12-10	12-10	12-10	12-10	12-10	12-10	12-10	12-10
C—Rear Space	22	22	22	22	22	22	24	24	24	24	24	24	28	28
D—Thickness Wall	9	9	9	9	9	9	13	13	13	13	13	13	13	13
E—Length Grate	37	37	37	43	43	43	49	49	55	55	61	61	67	67
F—Width Ash-pit	9	9	9	13	13	13	17	17	17	17	17	17	17	17
G—Thickness Bridge Wall	9	9	9	13	13	13	17	17	17	17	17	17	17	17
H—Grate to Tube Sheet	17	17	17	23	23	23	29	29	35	35	41	41	47	47
I—Header to Bridge Wall	17	17	17	23	23	23	29	29	35	35	41	41	47	47
J—Height Brickwork	83	83	83	90	90	90	96	96	102	102	108	108	114	114
K—Location Steam Supply	7-6	8-0	8-0	8-10	8-10	8-10	8-10	8-10	8-10	8-10	8-10	8-10	8-10	8-10
L—Length Over-all	12-5	12-5	12-5	12-5	12-5	12-5	12-5	12-5	12-5	12-5	12-5	12-5	12-5	12-5
M—Height Water-line	58 1/2	58 1/2	58 1/2	61	61	61	66	66	71	71	76	76	81 1/2	81 1/2
N—Height Side Flue	39	39	39	42	42	42	48	48	54	54	60	60	66	66
O—Diameter Breaching Connection	24	24	24	24	24	24	27	27	30	30	34	34	38	38
P—Height Brick Shelf	50	50	50	53	53	53	57	57	63	63	69	69	75	75
Q—Top Flue Space	7	7	7	8	8	8	8	8	10	10	10	10	10	10
R—Length Brick Shelf	36	36	36	40	40	40	46	46	52	52	58	58	64	64
S—Length of Arch	7-0	7-0	7-0	7-0	7-0	7-0	7-0	7-0	7-0	7-0	7-0	7-0	7-0	7-0
T—Width Over-all	6-0	6-0	6-0	6-0	6-0	6-0	6-0	6-0	6-0	6-0	6-0	6-0	6-0	6-0
U—Width Double Setting	11-3	11-3	11-3	11-3	11-3	11-3	11-3	11-3	11-3	11-3	11-3	11-3	11-3	11-3
Number Common Brick	2500	2500	2500	2700	2700	2700	3000	3000	3300	3300	3600	3600	4000	4000
Number Fire Brick	100	100	100	100	100	100	100	100	100	100	100	100	100	100
Common Brick for Two Boilers	4000	4000	4000	4200	4200	4200	4600	4600	5000	5000	5400	5400	6000	6000

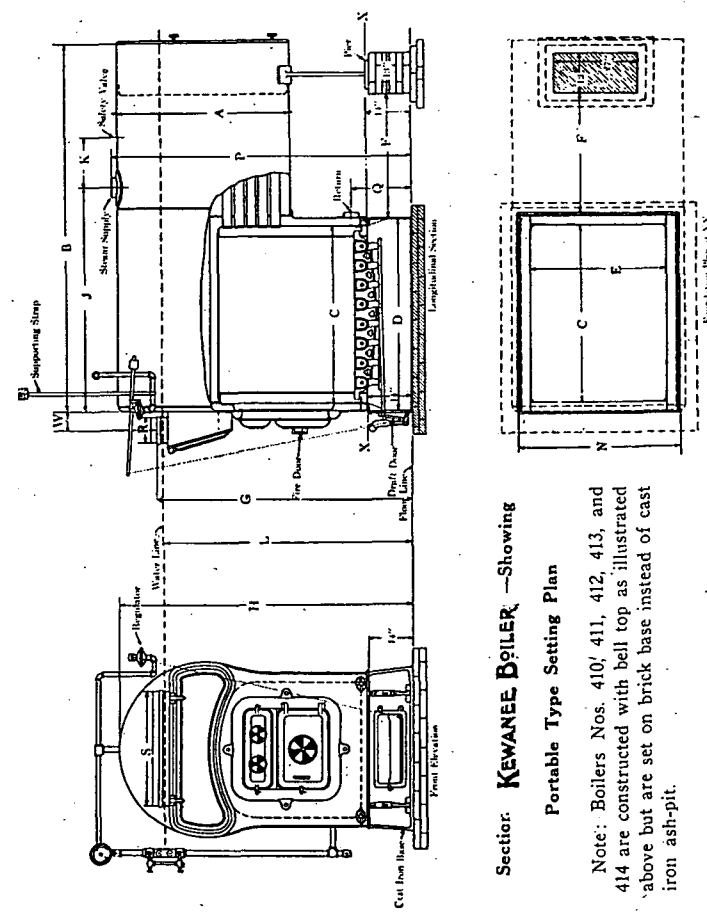
*Foundations not included.
Key letters N and V apply only to boiler settings with breaching connection at front. Key letters R and T apply only to boiler settings with breaching connection at rear.





Section KEWANEE SMOKELESS BOILER

Showing Portable Type Setting
Plan and Foundation



Section: KEWANEE BOILER —Showing

Portable Type Setting Plan

Note: Boilers Nos. 410, 411, 412, 413, and 414 are constructed with bell top as illustrated above but are set on brick base instead of cast iron ash-pit.

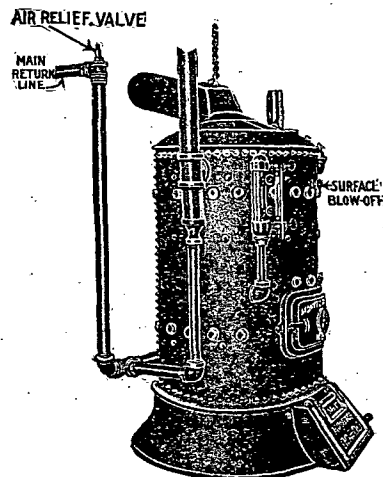
Monitor Bi-Loop Radiator Co.

Lancaster, Pa.

Sales Department: Finance Building, Philadelphia, Pa.

Branch Offices in Principal Cities

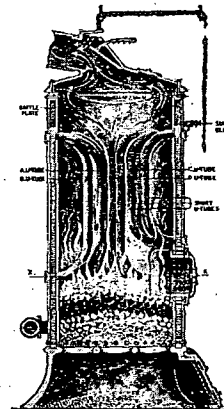
Monitor "U" Tube Boilers, Monitor Bi-Loop Radiators, Steam Water Heaters,
Bi-Loop Main Line Vent Valves



No. 64.

Monitor "U" Tube Boilers are constructed of steel, in accordance with A. S. M. E. Boiler Code. They are highly efficient due to the construction of the heating surface, which is nearly all direct, there being no place for soot or fine ash to accumulate and retard transmission of heat. Constructed for any working pressure and suitable for steam and hot water heating, domestic hot water and for producing steam for dairies, bakeries, candy factories, dyeing establishments, hotel and restaurant kitchens, etc.

We will be glad to send descriptive literature upon request, if further information or data are desired.



Monitor "U" Tube Boilers

Boiler Number	Grate Area	Steam Rating Sq. Feet	Water Rating Sq. Feet
17	1.6	400	640
20-1	2.2	500	800
2	2.2	600	960
23-1	2.9	700	1120
2	2.9	800	1280
25-1	3.7	900	1340
2	3.7	1000	1600
28-1	4.3	1150	1840
2	4.3	1300	2080
31-1	5.3	1500	2400
2	5.3	1800	2880
3	5.3	2150	3440
35-1	6.7	2500	4000
2	6.7	3000	4800
3	6.7	3500	5600
40-1	8.8	4000	6400
2	8.8	4750	7600
40-01	10.75	5600	8960
40-02	13.44	7000	11200
48-01	16.32	8500	13600
48-02	19.02	10000	16000

WATER HEATER RATINGS

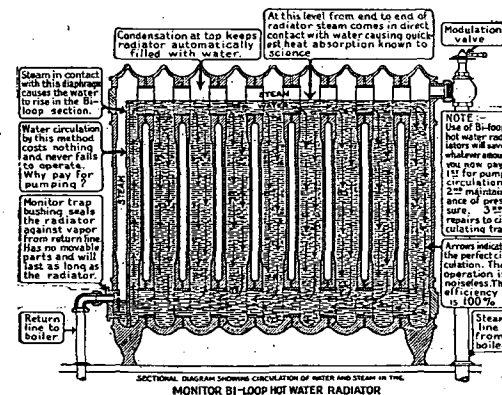
Boiler No.	Grate Area	-25	30	40	50	60	70	80	100	120	150
17	1.6	480	400	300	240	200	170	150	120	100	80
20-1	2.2	640	490	400	320	245	225	200	160	125	100
2	2.2	695	577	433	347	288	247	216	173	145	115
23-1	2.9	827	688	517	413	344	295	258	206	172	137
2	2.9	958	797	600	479	398	342	300	240	199	160
25-1	3.7	1056	878	660	528	439	376	330	264	220	175
2	3.7	1167	971	729	583	485	416	364	291	242	195
28-1	4.3	1356	1128	847	678	564	484	423	339	282	226
2	4.3	1550	1288	968	775	644	553	484	387	322	258
31-1	5.3	1751	1457	1094	875	728	625	544	437	364	292
2	5.3	2064	1720	1290	1032	860	738	645	516	430	344
3	5.3	2472	2056	1542	1236	1028	880	771	618	514	412
35-1	6.7	2916	2428	1821	1458	1214	1041	910	729	607	486
2	6.7	3522	2932	2199	1761	1466	1256	1099	880	733	587
3	6.7	4026	3352	2514	2013	1671	1436	1307	1006	838	671
40-1	8.8	4626	3852	2789	2313	1926	1650	1394	1156	963	771
2	8.8	5544	4620	3465	2772	2310	1981	1732	1386	1155	924

Monitor Bi-Loop Hot Water Radiators are partly filled with water which is heated by steam within the radiator, thereby eliminating the large volume of water to be circulated in the direct hot water system, and eliminating 95% of the air that is found in a steam or vapor radiator. They are constructed of cast iron

having same heating surface as any standard make of radiator; the end section has a diaphragm which acts as a dividing line between the water and steam; it also acts as a transmitting medium to circulate the water in the radiator.

Monitor Bi-Loop Radiators are assembled in any standard units and will transmit approximately 200 B. T. U. per sq. ft. of surface.

We will gladly send catalogue describing the system more fully.



Oil City Boiler Works

Oil City, Pa.

BRANCH OFFICES:

NEW YORK, 501 Fifth Avenue

PITTSBURGH, House Building

CHICAGO, 1224 Marquette Building

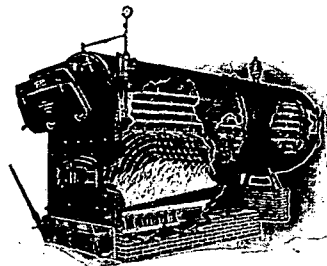
REPRESENTATIVES:

Cleveland, Ohio

San Francisco, Cal.

Philadelphia, Pa.

Baltimore, Md.



"Oil City" Direct Draft 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.

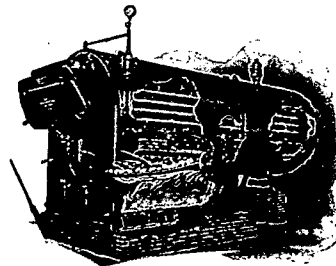
"OIL CITY" boilers are designed and constructed to meet all requirements of modern engineering as formulated by the American Society of Mechanical Engineers, the boiler laws of the various states and cities, and are backed by thirty-five years of successful practical experience.

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 lbs. 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



"Oil City" Smokeless Boiler

space, insuring dry steam and steady water level.

All parts of the boiler are made accessible for cleaning by the use of man-holes, 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.

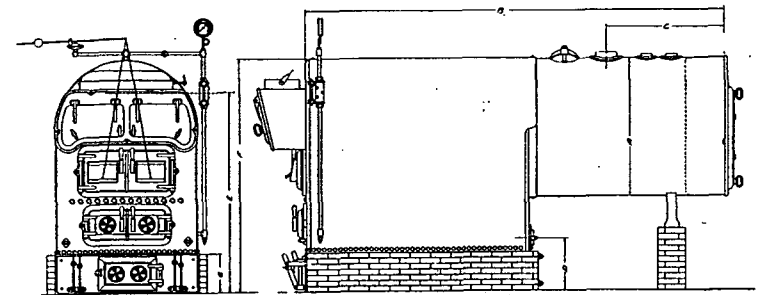
In General

In addition to the foregoing, the object of the OIL CITY BOILER WORKS is to furnish a boiler that has embodied in it the best features of modern construction and free from the recognized faults.

Every "OIL CITY" boiler bears the official stamp, or symbol 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 lbs.

SPECIFICATIONS AND GENERAL DIMENSIONS ON NEXT PAGE.



Setting Plan and Measurements "Oil City" Heating Boilers

"Oil City" Smokeless

NUMBER OF BOILER	307	308	309	310	311	312	313	314	315	316	317	318	319	320	321	322	323	324
CAPACITY - STEAM	30 FT	3000	3000	3000	3000	3000	3000	3000	3000	3000	3000	3000	3000	3000	3000	3000	3000	3000
CAPACITY - WATER	30 FT	3000	3000	3000	3000	3000	3000	3000	3000	3000	3000	3000	3000	3000	3000	3000	3000	3000
BOILER DIAMETER	A	48	48	48	48	48	48	48	48	48	48	48	48	48	48	48	48	48
BOILER LENGTH	B	14' 0"	14' 0"	14' 0"	14' 0"	14' 0"	14' 0"	14' 0"	14' 0"	14' 0"	14' 0"	14' 0"	14' 0"	14' 0"	14' 0"	14' 0"	14' 0"	14' 0"
FEET TO OUTLET	C	14' 0"	14' 0"	14' 0"	14' 0"	14' 0"	14' 0"	14' 0"	14' 0"	14' 0"	14' 0"	14' 0"	14' 0"	14' 0"	14' 0"	14' 0"	14' 0"	14' 0"
FLOOR TO RETURN	D	14' 0"	14' 0"	14' 0"	14' 0"	14' 0"	14' 0"	14' 0"	14' 0"	14' 0"	14' 0"	14' 0"	14' 0"	14' 0"	14' 0"	14' 0"	14' 0"	14' 0"
FLOOR TO WATER LINE	E	14' 0"	14' 0"	14' 0"	14' 0"	14' 0"	14' 0"	14' 0"	14' 0"	14' 0"	14' 0"	14' 0"	14' 0"	14' 0"	14' 0"	14' 0"	14' 0"	14' 0"
HEIGHT OVER BOILER	F	14' 0"	14' 0"	14' 0"	14' 0"	14' 0"	14' 0"	14' 0"	14' 0"	14' 0"	14' 0"	14' 0"	14' 0"	14' 0"	14' 0"	14' 0"	14' 0"	14' 0"
HEIGHT FROM PIT	G	14' 0"	14' 0"	14' 0"	14' 0"	14' 0"	14' 0"	14' 0"	14' 0"	14' 0"	14' 0"	14' 0"	14' 0"	14' 0"	14' 0"	14' 0"	14' 0"	14' 0"
SIZE OUTLET	H	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
SIZE RETURN	I	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
SIZE SMOKE OUTLET	J	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
PIPE BREACHING - ONE BOILER	K	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22
PIPE BREACHING - TWO BOILERS	L	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30
PIPE STRUCK - ONE BOILER	M	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20
PIPE STRUCK - TWO BOILERS	N	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20
HEIGHT STRUCK - ONE BOILER	O	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20
HEIGHT STRUCK - TWO BOILERS	P	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20
FEET TO OPEN KICK ROADS	Q	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20

"Oil City" Direct Draft Type

NUMBER OF BOILER	307	308	309	310	311	312	313	314	315	316	317	318	319	320	321	322	323	324
CAPACITY - STEAM	30 FT	3000	3000	3000	3000	3000	3000	3000	3000	3000	3000	3000	3000	3000	3000	3000	3000	3000
CAPACITY - WATER	30 FT	3000	3000	3000	3000	3000	3000	3000	3000	3000	3000	3000	3000	3000	3000	3000	3000	3000
BOILER DIAMETER	A	48	48	48	48	48	48	48	48	48	48	48	48	48	48	48	48	48
BOILER LENGTH	B	14' 0"	14' 0"	14' 0"	14' 0"	14' 0"	14' 0"	14' 0"	14' 0"	14' 0"	14' 0"	14' 0"	14' 0"	14' 0"	14' 0"	14' 0"	14' 0"	14' 0"
FEET TO OUTLET	C	14' 0"	14' 0"	14' 0"	14' 0"	14' 0"	14' 0"	14' 0"	14' 0"	14' 0"	14' 0"	14' 0"	14' 0"	14' 0"	14' 0"	14' 0"	14' 0"	14' 0"
FLOOR TO RETURN	D	14' 0"	14' 0"	14' 0"	14' 0"	14' 0"	14' 0"	14' 0"	14' 0"	14' 0"	14' 0"	14' 0"	14' 0"	14' 0"	14' 0"	14' 0"	14' 0"	14' 0"
FLOOR TO WATER LINE	E	14' 0"	14' 0"	14' 0"	14' 0"	14' 0"	14' 0"	14' 0"	14' 0"	14' 0"	14' 0"	14' 0"	14' 0"	14' 0"	14' 0"	14' 0"	14' 0"	14' 0"
HEIGHT OVER BOILER	F	14' 0"	14' 0"	14' 0"	14' 0"	14' 0"	14' 0"	14' 0"	14' 0"	14' 0"	14' 0"	14' 0"	14' 0"	14' 0"	14' 0"	14' 0"	14' 0"	14' 0"
HEIGHT FROM PIT	G	14' 0"	14' 0"	14' 0"	14' 0"	14' 0"	14' 0"	14' 0"	14' 0"	14' 0"	14' 0"	14' 0"	14' 0"	14' 0"	14' 0"	14' 0"	14' 0"	14' 0"
SIZE OUTLET	H	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
SIZE RETURN	I	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
SIZE SMOKE OUTLET	J	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
PIPE BREACHING - ONE BOILER	K	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22
PIPE BREACHING - TWO BOILERS	L	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30
PIPE STRUCK - ONE BOILER	M	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20
PIPE STRUCK - TWO BOILERS	N	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20
HEIGHT STRUCK - ONE BOILER	O	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20
HEIGHT STRUCK - TWO BOILERS	P	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20
FEET TO OPEN KICK ROADS	Q	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20

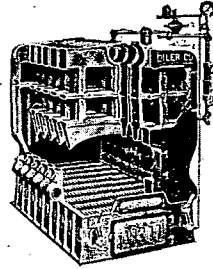
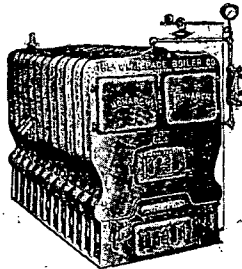
The Wm. H. Page Boiler Co.

GENERAL OFFICES:

141-145 West 36th Street
New York

Branches: 379 Commercial Street, Boston. 1718 Sansom Street, Philadelphia. Rose Building, Cleveland. Factory: Meadville, Pa.

Manufacturers of a Complete Line of Round and Square Steam and Hot Water Boilers



Monarch Up-Draft Smokeless Monarch Regular Type, Sectional View
† Monarch Sectional Steam and Water Boilers
Dimensions and Ratings

Number	8 Hour Rating* Sq. Ft. Steam	8 Hour Rating* Sq. Ft. Water	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
P604	650	1075	22x20	3.35	62	41	52	34	34	41	2-3	10
P605	850	1400	22x26 1/4	4.03	62	41	52	34	40 3/4	41	2-3	10
P606	1050	1725	22x32 1/4	5.00	62	41	52	34	46 3/4	41	2-3	10
P607	1250	2050	22x39 1/4	5.98	62	41	52	34	53 1/4	41	2-3	10
P608	1450	2400	22x45 1/4	6.95	62	41	52	34	59 1/4	41	2-3	10
P504	1200	1975	28x24 1/4	4.82	74	48	64	40	43 1/4	51	2-5	13
P505	1600	2625	28x33 1/4	6.45	74	48	64	40	52	51	2-5	13
P506	2000	3300	28x41 1/4	8.07	74	48	64	40	60 1/4	51	2-5	13
P507	2400	3950	28x49 1/4	9.70	74	48	64	40	68 1/4	51	2-5	13
P508	2800	4600	28x58 1/4	11.32	74	48	64	40	77 1/4	51	2-5	13
P509	3200	5275	28x66 1/4	12.96	74	48	64	40	85 1/4	51	2-5	13
P510	3600	5950	28x66 1/4	12.96	74	48	64	40	93 1/4	51	2-5	13
P511	4000	6625	28x66 1/4	12.96	74	48	64	40	102 1/4	51	2-5	13
P512	4400	7300	28x66 1/4	12.96	74	48	64	40	110 1/4	51	2-5	13
P405	2400	3975	40x33 1/4	9.55	82	63	72	54	52	55	2-5	21
P406	3000	4950	40x41 1/4	11.52	82	63	72	54	60 3/4	55	2-5	21
P407	3600	5925	40x49 1/4	13.85	82	63	72	54	68 3/4	55	2-5	21
P408	4200	6925	40x58 1/4	16.18	82	63	72	54	77 1/4	55	2-5	21
P409	4800	7925	40x66 1/4	18.50	82	63	72	54	85 1/4	55	2-5	21
P410	5400	8900	40x75	20.82	82	63	72	54	93 1/4	55	2-5	21
P411	6000	9900	40x83 1/4	23.13	82	63	72	54	102 1/4	55	3-5	21
P412	6600	10900	40x91 1/4	25.50	82	63	72	54	110 1/4	55	3-5	21
P413	7200	11875	40x91 1/4	25.50	82	63	72	54	119 1/4	55	3-5	21
P414	7800	12875	40x91 1/4	25.50	82	63	72	54	127 1/4	55	3-5	21
P415	8400	13850	40x91 1/4	25.50	82	63	72	54	135 1/4	55	3-5	21
P416	9000	14850	40x91 1/4	25.50	82	63	72	54	144 1/4	55	3-5	21

† Bridgwall sections are furnished for shortening grates, if desired, and are recommended for boilers above nine sections. They are regularly shipped with boilers larger than P509 and P412 to reduce grate to length in table of dimensions.

† These boilers can also be furnished with Header Connections, and in both Up-Draft and Down-Draft Smokeless types.

* Monarch boilers are built in conformity with the Boiler Code of the American Society of Mechanical Engineers; and ratings as given are conservatively made in accordance with the Standard Formula of the American Society of Heating and Ventilating Engineers, are derived from careful and exhaustive tests which proved their safety, and are based on a standard of 2 lbs. pressure maintained at the boiler for steam and 180 degrees for hot water.

Pierce, Butler & Pierce Mfg. Corp.

Liggett Building

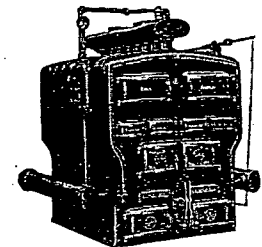
New York City

Factories: Eastwood, Syracuse and Oswego, N. Y.; Huntingdon, Pa.
Branch Offices: New York, Brooklyn, Syracuse, Newark, Worcester, Boston, Philadelphia, Detroit.

Cast iron water boilers 100 to 14,950 sq. ft. capacity. Cast iron steam boilers 325 to 9,000 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

The boiler with a thirty
year record of proved suc-
cessful performance.



Sizes and Dimensions

Number*	Number Sections	Length Boiler	Width Boiler & Headers	Height Boiler & Headers	Height Water Line on Steam Boilers	Number & Size Outlets	Number & Size Returns	Diameter Smoke Pipe	Size of Flue	Height of Chimney	Capacity Sq. Ft. Steam Boilers	Capacity Sq. Ft. Water Boilers
214	4	47	45	56 1/4	40 1/4	2-3	2-3	9 1/2	8x12	35 ft.	600	1000
215	5	55	45	56 1/4	40 1/4	2-3	2-3	9 1/2	8x12	35 ft.	800	1325
216	6	63	45	56 1/4	40 1/4	2-3	2-3	9 1/2	12x12	40 ft.	1000	1650
217	7	71	45	58	40 1/4	2-3	2-4	9 1/2	12x12	40 ft.	1200	2000
265	5	55	51	64 1/4	47 1/4	2-3	2-3	11 1/4	12x12	40 ft.	1100	1825
266	6	63	51	64 1/4	47 1/4	2-4	2-4	11 1/4	12x12	40 ft.	1400	2325
267	7	71	51	64 1/4	47 1/4	2-4	2-4	11 1/4	12x16	50 ft.	1700	2825
268	8	79	51	64 1/4	47 1/4	2-4	2-4	11 1/4	12x16	50 ft.	2000	3300
325	5	55	59 1/4	67	49	2-4	2-4	14	12x16	40 ft.	1400	2325
326	6	63	59 1/4	67	49	2-5	2-5	14	12x16	40 ft.	1750	2900
327	7	71	59 1/4	67	49	2-5	2-5	14	16x16	40 ft.	2100	3475
328	8	79	59 1/4	67	49	2-5	2-5	14	16x16	50 ft.	2450	4050
329	9	87	59 1/4	67	49	2-5	2-5	14	16x16	50 ft.	2800	4450
405	5	55	66 1/4	69 1/4	51	2-4	2-4	15 1/4	12x16	40 ft.	1900	4625
406	6	63	66 1/4	69 1/4	51	2-5	2-5	15 1/4	16x16	40 ft.	2400	3150
407	7	71	66 1/4	69 1/4	51	2-5	2-5	15 1/4	16x16	50 ft.	2900	3975
408	8	79	66 1/4	69 1/4	51	2-5	2-5	15 1/4	16x20	50 ft.	3400	4800
409	9	87	66 1/4	69 1/4	51	2-5	2-5	15 1/4	20x20	50 ft.	3900	5625
4010	10	95	66 1/4	69 1/4	51	2-5	2-5	15 1/4	20x20	50 ft.	4400	7250
466	6	68	78 1/4	82	55 1/4	2-6	2-6	19 1/4	20x20	50 ft.	3750	6200
467	7	76	78 1/4	82	55 1/4	2-6	2-6	19 1/4	20x20	50 ft.	4500	7450
468	8	84	78 1/4	82	55 1/4	2-6	2-6	19 1/4	20x20	60 ft.	5250	8700
469	9	92	78 1/4	82	55 1/4	2-6	2-6	19 1/4	20x20	60 ft.	6000	9950
4610	10	100	78 1/4	82	55 1/4	2-6	2-6	19 1/4	24x24	60 ft.	6750	11200
4611	11	108	78 1/4	82	55 1/4	2-6	2-6	19 1/4	24x24	60 ft.	7500	12450
4612	12	116	78 1/4	82	55 1/4	2-6	2-6	19 1/4	24x24	70 ft.	8250	13700
4613	13	124	78 1/4	82	55 1/4	2-6	2-6	19 1/4	24x24	70 ft.	9000	14950

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 grate sections for brick fire wall to reduce size of grate will be supplied without extra charge with boiler if so ordered.

* 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.

The Prudential Heater Co.

Incorporated -
Louisville, Ky.

Manufacturers of "Prudential" Smokeless Down Draft Boilers, "Prudential" Line Direct Radiation, "Prudential" Laundry Tank Heaters.

"Prudential" Down Draft Boilers

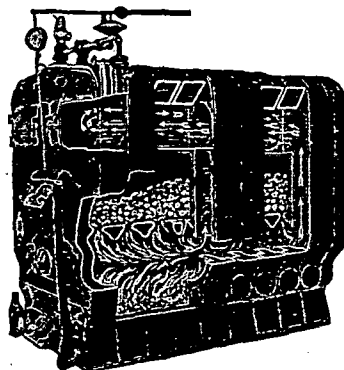
Will burn any grade soft coal smokelessly.

Double Water Legs permit the use of each section to the rear for firing.

Extreme depth and height of upper combustion chamber permit large storage of coal, requiring less attention by owners.

Long, round, smooth flues.

Guaranteed ratings.



"Prudential" Smokeless Down Draft Boilers—Steam.

Boiler Number	Rating Square Feet	Price Each	Combined Grate Area, Sq. Ft.	Water Line, Inches	Height, Inches, Less Trimmings	Width, Inches	Front Length, Inches, to Back of Smoke Hood	Outlet, Size and Number	Returns, Size and Number	Smoke Pipe, Size, Inches	Number of Sections
250	1250	\$ 580.00	8.33	57	65	37	60	2-4"	2-3"	12	5
260	1550	\$ 445.00	10.27	57	65	37	68	2-4"	2-3"	12	6
270	1850	\$ 507.00	12.50	57	65	37	76	2-4"	2-3"	12	7
280	2150	\$ 564.00	14.72	57	65	37	82	3-4"	3-3"	12	8
360	2400	\$ 621.00	17.88	61	70	48	66	2-4"	2-3"	12	6
370	2700	\$ 678.00	21.00	61	70	48	75	2-4"	2-3"	14	7
380	3000	\$ 735.00	24.11	61	70	48	83	3-4"	3-3"	14	8
390	3500	\$ 830.00	28.00	61	70	48	93	3-4"	3-3"	14	9
366	4000	\$ 925.00	23.00	68	80	63	67	3-4"	3-3"	16	6
3100	4500	\$1,020.00	31.11	61	70	48	101	2-5"	2-4"	14	10
376	9000	\$1,115.00	27.00	68	80	63	75	2-5"	2-4"	16	7
386	5600	\$1,210.00	31.00	68	80	63	83	3-5"	3-4"	16	8
396	6400	\$1,475.00	35.50	68	80	63	92	3-5"	3-4"	18	9
3106	7200	\$1,680.00	40.00	68	80	63	101	3-5"	3-4"	18	10
3116	8100	\$1,885.00	44.50	68	80	63	110	3-6"	3-4"	18	11
3126	9000	\$2,090.00	49.00	68	80	63	119	3-6"	3-4"	18	12
3136	9900	\$2,295.00	53.50	68	80	63	128	3-6"	3-4"	18	13

Reading Heater & Supply Co.

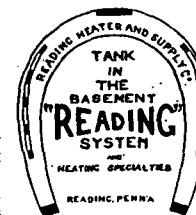
Incorporated
GENERAL OFFICES
Woodward and Church Streets
Reading, Pa.

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 in-



creased 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)

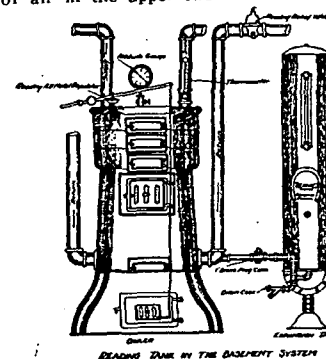
- No. 1, 300 to 500 feet of Radiation \$38
- No. 2, 500 to 800 feet of Radiation 40
- No. 3, 800 to 1000 feet of Radiation 41
- No. 4, 1000 to 1300 feet of Radiation 45
- No. 5, 1300 to 1800 feet of Radiation 50
- No. 6, 1800 to 2600 feet of Radiation 56

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.

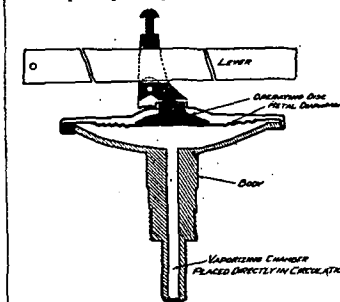
The Reading All-Metal Regulator can be used to control water temperature in any system, regardless of pressure carried. The Regulator is easily applied and the action is sensitive and reliable.

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.



READING TANK IN THE BASEMENT SYSTEM



INTERIOR VIEW
READING ALL-METAL TEMPERATURE REGULATOR

Boilers

Richardson & Boynton

260 Fifth Avenue
New York City

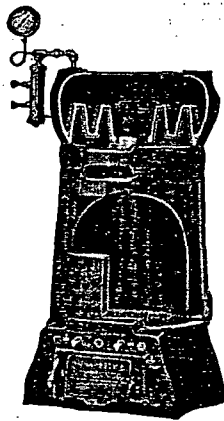
BRANCHES

Boston
60 High Street
Providence
429 Industrial Trust Building

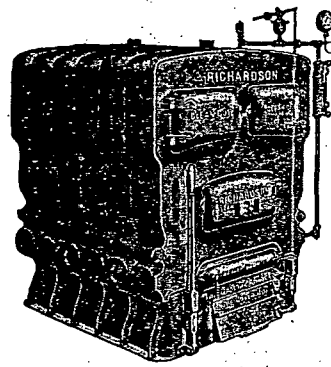
Chicago
171-173 West Lake Street

Philadelphia
1332 Arch Street
Rochester
Rockwood Street

Richardson Round Boiler



Richardson Sectional Boiler



List Prices and Data

Round

Boiler Number	8 Hr. Rating Sq. Ft. Steam	8 Hr. Rating Sq. Ft. Water	Nom. Diam. Grate, Inches	Grate Area, Sq. Ft.	No. Inlets and Outlets and Size, inches	List Price Complete, Steam	List Price Water Complete, Water
161	250	400	16	1.40	2-2	118.00	103.00
162	275	425	16	1.40	2-2	135.00	113.00
190	300	500	19	1.97	2-2½	142.00	116.00
191	350	575	19	1.97	2-2½	158.00	133.00
192	375	625	19	1.97	2-2½	175.00	146.00
221	450	750	22	2.64	2-2½	194.00	160.00
222	500	825	22	2.64	2-2½	207.00	177.00
223	550	900	22	2.64	2-2½	220.00	192.00
251	625	1025	25	3.41	2-3	242.00	202.00
252	675	1100	25	3.41	2-3	258.00	215.00
253	725	1200	25	3.41	2-3	283.00	242.00
281	875	1350	28	4.28	2-3½	295.00	250.00
282	950	1550	28	4.28	2-3½	322.00	273.00
283	1025	1675	28	4.28	2-3½	355.00	308.00

Sectional

Boiler Number	8 Hr. Rating Sq. Ft. Steam	8 Hr. Rating Sq. Ft. Water	Grate Area, Sq. Ft.	Asphalt, Inside; Inches	No. Outlets and Size, inches	List Price Complete, Steam	List Price Complete, Water	
255	1000	1600	4.57	27½	35½	2-3½	361.00	328.00
256	1250	2000	5.70	27½	42½	2-3½	430.00	397.00
257	1500	2400	6.83	27½	50	2-3½	490.00	457.00
258	1700	2800	7.97	27½	57½	2-3½	547.00	514.00
355	1950	3125	7.85	39	33½	2-4	590.00	548.00
356	2400	3850	9.81	39	41½	2-4	700.00	658.00
357	2850	4575	11.75	39	50	3-4	810.00	768.00
358	3300	5300	13.70	39	58½	3-4	900.00	850.00
359	3750	6025	15.65	39	66½	3-4	990.00	940.00
427	3500	5600	13.82	45	50	2-5	942.00	892.00
428	4050	6500	16.11	45	58½	2-5	1,035.00	985.00
429	4600	7400	18.40	45	66½	2-5	1,150.00	1,085.00
4210	5150	8300	20.69	45	74½	3-5	1,245.00	1,180.00
4211	5700	9200	22.98	45	83	3-5	1,345.00	1,275.00
536	6300	10000	18.94	55	55	2-6	1,553.00	1,495.00
537	7300	11600	22.68	55	65½	2-6	1,748.00	1,685.00
538	8300	13200	26.40	55	76½	3-6	1,950.00	1,870.00
539	9300	14800	30.12	55	87½	3-6	2,143.00	2,060.00
5310	10300	16400	33.88	55	98	3-6	2,354.00	2,250.00

Boilers

Standard Heater Company

Williamsport, Pa.

NEW YORK PHILADELPHIA BOSTON BALTIMORE BUFFALO
DETROIT CHICAGO DENVER DULUTH

Builders of Spencer Heaters



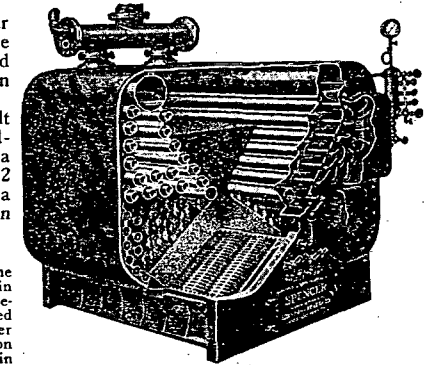
Spencer Heaters

Give uniform heat over long periods and use small size cheap 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.

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 hrs. Therefore ratings of Spencer Heaters are based upon an evaporation of 8 lbs. of water per pound of coal burned, the rated evaporation having been obtained in actual test made in accordance with the A. S. H. & V. E. code for testing low pressure boilers, using fresh-mined No. 1 Buckwheat coal as fuel.



Tubular-Spencer Steam Heater

Spencer Sectional Steam and Water Heaters

Number	Steam Rating	Sq. Ft. Grate	Tapping Flow	Tapping Return	Length Over All inches	Width In.	Water Line	Number	Water Rating	Chimney Flue
15-4S	375	2.29	1-4"	2-3"	33"	33½"	49"	15-4W	600	8x 8x30
15-5S	500	3.02	1-4"	2-3"	39½"	33½"	49"	15-5W	800	8x 8x30
15-6S	625	3.78	1-4"	2-3"	47"	33½"	49"	15-6W	1000	10x10x35
15-7S	750	4.54	2-4"	4-3"	54"	33½"	49"	15-7W	1200	10x10x35
15-8S	900	5.30	2-4"	4-3"	62"	33½"	49"	15-8W	1400	10x10x40
27-4S	1000	4.38	3-4"	3-4"	41½"	55½"	53"	27-4W	1600	10x10x35
27-5S	1300	5.84	3-4"	3-4"	49½"	55½"	53"	27-5W	2100	10x10x40
27-6S	1600	7.31	3-4"	3-4"	58"	55½"	53"	27-6W	2600	12x12x35
27-7S	1900	8.78	3-4"	3-4"	66"	55½"	53"	27-7W	3100	12x12x40
27-8S	2200	10.29	3-4"	3-4"	74"	55½"	53"	27-8W	3600	12x12x40
30-6S	1800	8.60	2-5"	2-5"	56"	64"	54"	30-6W	2750	12x12x35
30-7S	2100	10.32	2-5"	2-5"	64"	64"	54"	30-7W	3300	12x12x35
30-8S	2400	12.04	2-5"	2-5"	73"	64"	54"	30-8W	3850	12x12x40
30-9S	2800	13.76	2-5"	2-5"	81"	64"	54"	30-9W	4400	12x12x40

Spencer Tubular Steam Heaters

Number	Steam Rating	Sq. Ft. Grate	Tapping Flow	Tapping Return	Length Over All inches	Width In.	Water Line	Number	Water Rating	Chimney Flue
9	1100	7.00	2-4"	2-3"	57"	51"	51"			12x12x40
11	1400	8.16	2-4"	2-3"	63"	51"	51"			12x12x40
13	1700	9.33	2-4"	2-3"	70"	51"	51"			12x12x45
15	2000	9.50	2-4"	2-3"	71"	60"	56"			16x16x50
17	2500	10.68	2-4"	2-3"	77"	60"	56"			16x16x55
19	3000	11.87	2-4"	2-3"	83"	60"	56"			16x16x60
20	3500	13.06	2-4"	2-3"	89"	60"	56"			16x16x65
21	4000	14.25	2-4"	2-3"	95"	60"	56"			16x16x65
*3-45	4500	12.5	2-5"	1-4"	101½"	81"	59"			18x18x50
*3-50	5000	14.0	2-5"	1-4"	107½"	81"	59"			18x18x50
*3-55	5500	15.6	2-5"	1-4"	114"	81"	59"			18x18x60
*3-60	6000	17.2	2-5"	1-4"	120½"	81"	59"			18x18x60
*3-70	7000	18.75	2-5"	1-4"	126½"	81"	59"			20x20x65
*3-80	8000	21.9	1-8"	1-4"	95½"	108"	66"			20x20x65
*3-90	9000	25.0	1-8"	1-4"	101½"	108"	66"			22x22x65
*3-105	10500	28.1	1-8"	1-4"	107½"	108"	66"			24x24x70
*3-120	12000	31.25	1-8"	1-4"	114"	108"	66"			24x24x70
*3-140	14000	34.4	1-8"	1-4"	120½"	108"	66"			24x24x70

* Heaters No. 3-45 to 3-140 are furnished with jackets and covering, also pipe header and smoke pipe ell.

Boilers

The H. B. Smith Company

Works: Westfield, Mass.

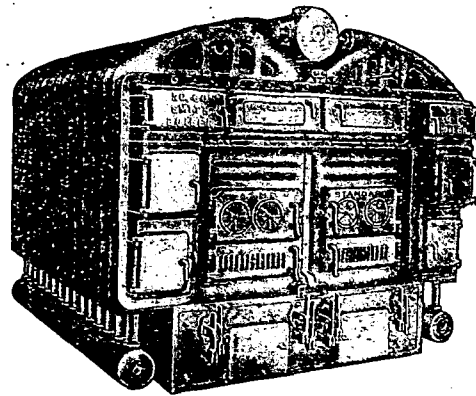
Westfield, Mass.: 57 Main Street

New York: 10 E. 39th Street

Boston: 640 Main Street, Cambridge

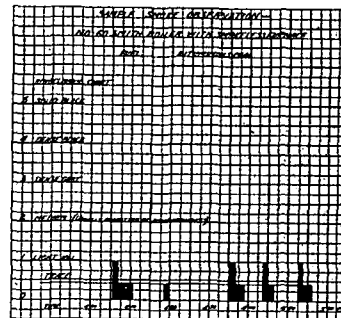
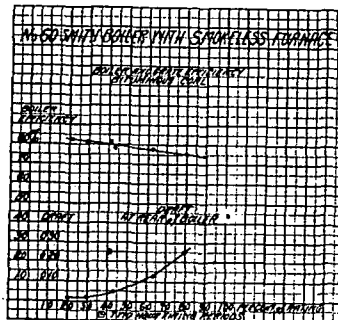
Philadelphia: 17th and Arch Streets

Manufacturers of Boilers and Radiators for Steam and Water Heating



No. 60 Smith Boiler

PERFORMANCE CURVES



To those interested other test records are available

H. B. Smith Company

Boilers

Smith Boiler With Smokeless Furnace

Smith Boiler Without Smokeless Furnace

No. of Sections in Boiler	Nominal Size of Fire Pot, Inches	Width	Length	Total Length of Boiler, Inches	Length at Foundation, Inches	Steam Rating, Feet	Water Rating, Feet
10	27	30	77	62	1500	2475	
11	27	30	83	68	1650	2725	
12	27	36	83	68	1800	2975	
12	27	36	89	74	1950	3225	
12	27	42	89	74	2100	3475	
13	27	42	95	80	2250	3725	
13	27	48	95	80	2400	3950	
14	27	48	101	86	2550	4200	
15	27	54	107	92	2725	4500	
16	27	60	113	98	2900	4775	
No. 36							
11	36	36	87	68	2750	4550	
12	36	36	93	74	3000	4950	
12	36	42	93	74	3250	5375	
13	36	42	99	80	3500	5775	
13	36	48	99	80	3750	6200	
14	36	48	105	86	4000	6600	
14	36	54	105	86	4250	7000	
15	36	54	111	92	4500	7425	
16	36	60	117	98	4800	7925	
17	36	66	123	104	5100	8425	
18	36	72	129	110	5400	8900	
No. 60							
12	60	36	110	73	6600	10900	
13	60	36	116	79	7200	11900	
13	60	42	116	79	7800	12850	
14	60	42	122	85	8400	13850	
14	60	48	122	85	9000	14850	
15	60	48	128	91	9600	15850	
15	60	54	128	91	10200	16850	
16	60	54	134	97	10800	17800	
17	60	60	140	103	12000	19800	
18	60	66	146	109	13200	21800	
19	60	72	152	115	14400	23750	
20	60	78	158	121	15600	25750	

Additional Data Applying to Boilers Both With and Without Smokeless Furnace

Boiler No.	27	36	60
Width at foundation	35	in. 48 1/4	in. 72 in.
Width of boiler, steam	56	in. 72	in. 98 in.
Width of boiler, water	59	in. 76	in. 98 in.
Height of boiler	80	in. 83	in. 87 in.
Height of water line	57	in. 59	in. 66 in.
Oval smoke pipe equiv.	13 3/4	in. 17	in. 26 in.
alent to	round	round	round

No. of Sections in Boiler	Nominal Size of Fire Pot, Inches	Width	Length	Total Length of Boiler, Inches	Length at Foundation, Inches	Steam Rating, Feet	Water Rating, Feet
5	27	24	47	32	1200	1975	
6	27	30	53	38	1500	2475	
7	27	36	59	44	1800	2975	
8	27	42	65	50	2100	3475	
9	27	48	71	56	2400	3950	
10	27	54	77	62	2700	4450	
11	27	60	83	68	3000	4950	
12	27	66	89	74	3300	5450	
13	27	66	95	80	3600	5950	
13	27	72	95	80	3600	5950	
14	27	66	101	86	3900	6425	
14	27	78	101	86	3900	6425	
No. 36							
7	36	36	63	44	2300	3800	
8	36	42	69	50	2800	4625	
9	36	48	75	56	3300	5450	
10	36	54	81	62	3800	6275	
11	36	60	87	68	4300	7100	
12	36	60	93	74	4800	7925	
12	36	66	93	74	4800	7925	
13	36	66	99	80	5300	8750	
13	36	72	99	80	5300	8750	
14	36	66	105	86	5800	9575	
14	36	78	105	86	5800	9575	
15	36	72	111	92	6300	10400	
15	36	84	111	92	6300	10400	
16	36	72	117	98	6800	11225	
16	36	90	117	98	6800	11225	
No. 60							
8	60	36	86	49	6000	9900	
9	60	42	92	55	7200	11900	
10	60	48	98	61	8400	13850	
11	60	54	104	67	9600	15850	
12	60	60	110	73	10800	17800	
13	60	66	116	79	12000	19800	
14	60	72	122	85	13200	21800	
15	60	78	128	91	14400	23750	
16	60	84	134	97	15600	25750	
17	60	78	140	103	16800	27700	
17	60	90	140	103	16800	27700	
18	60	84	146	109	18000	29700	
18	60	96	146	109	18000	29700	

Note.—For additional data pertaining to these boilers, see table at bottom of opposite column.

Tappings Supply Drum*

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.

No. of Sections	4	5	6	8
8	2	2	2	2
9	2	2	2	2
10	2	2	2	2
11	2	2	2	2
12	2	2	2	2
13	2	2	2	2
14	2	2	2	2
15	2	2	2	2
16	2	2	2	2
17	2	2	2	2
18	2	2	2	2
19	2	2	2	2
20	2	2	2	2

Return Drums*

Outside diameter.....8 in.
Tapped for 2-in. lock-nut nipples.
Front ends tapped.....2 1/2 in.
Rear ends tapped.....5 in.
Undersides tapped.....1 1/4 in.

Fire Tools Furnished

Poker, hoe, slice bar, flue brush with handle and ash shovel.

Trimings Furnished with Steam Boilers
Water column, gage cocks, water gage cocks, water gage glass, steam gage (with cock), steam gage siphon. Damper regulator complete with chain.

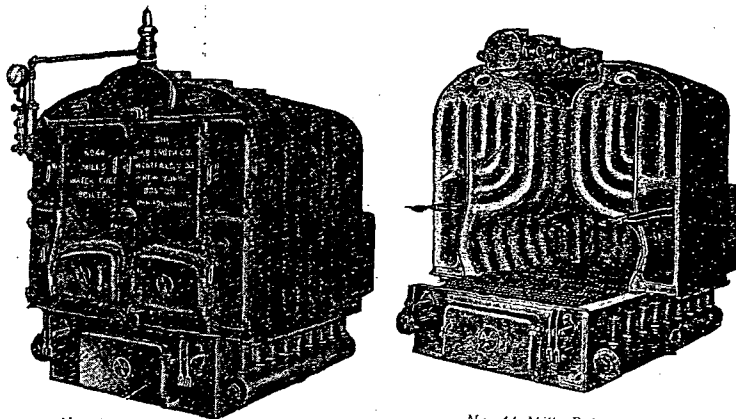
*When boiler is to be used for water warming, specify on order the size of supply and return pipe tappings. Tappings other than those listed are special. Order must specify sizes.

H. B. Smith Company

Boilers

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	Commercial Rating Capacity in Sq. Ft.		Max. Allowable Working Pressure		
		Steam	Water	Steam	Water (Open Tank)	Water (Closed Tank)
No. 24	24"	900 to 2025	1500 to 3350	15 lbs.	30 lbs.	15 lbs.
No. 34	34"	2000 to 5200	3300 to 8575	15 lbs.	30 lbs.	15 lbs.
No. 44	44"	3600 to 9000	5950 to 14850	15 lbs.	30 lbs.	15 lbs.
No. 48	48"	4800 to 12000	7925 to 19800	15 lbs.	60 lbs.	30 lbs.

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

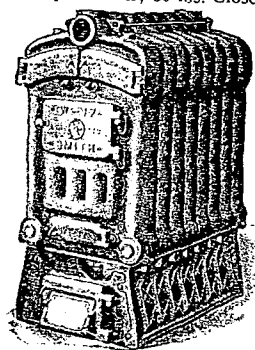
Diam. of Fire Pot Inches	Steam Rating Feet	Water Rating Feet
15 to 27	250 to 1000	425 to 1650

Smith Service Boiler W-17

For Hot Water Supply

A. S. M. E. Standard

Maximum allowable working pressure, 160 lbs. Open Tank; 80 lbs. Closed Tank.



H. B. Smith Company

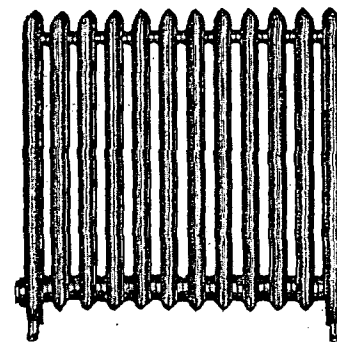
Boilers

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.

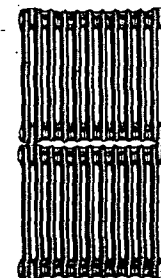
Princess Radiators are the standard radiators of The H. B. Smith Co. and are sold at regular list prices.



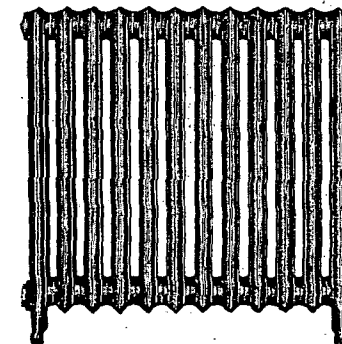
"Princess" Steam Radiator

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 inches. 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" Water Radiator

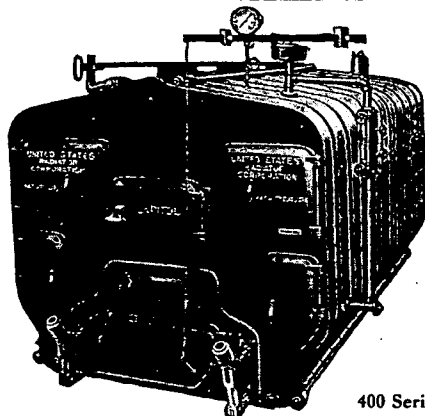
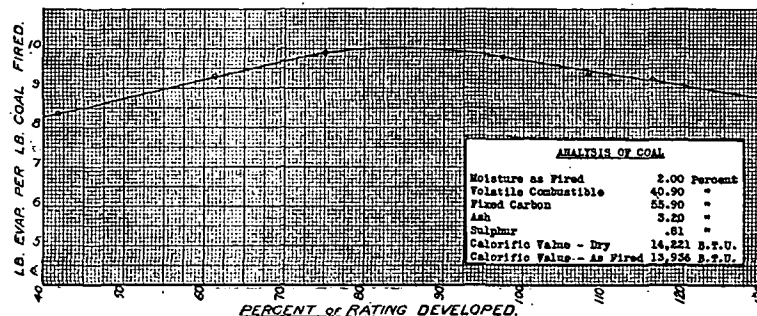
UNITED STATES RADIATOR CORPORATION

GENERAL OFFICES: DETROIT, MICHIGAN

Branch Offices in Principal Cities

Manufacturers of Capitol Boilers and United States Radiators

Performance Curve for No. 411 Capitol Smokeless Boiler



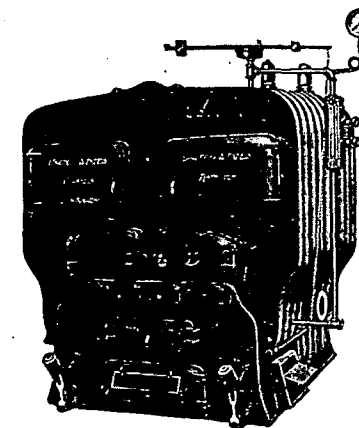
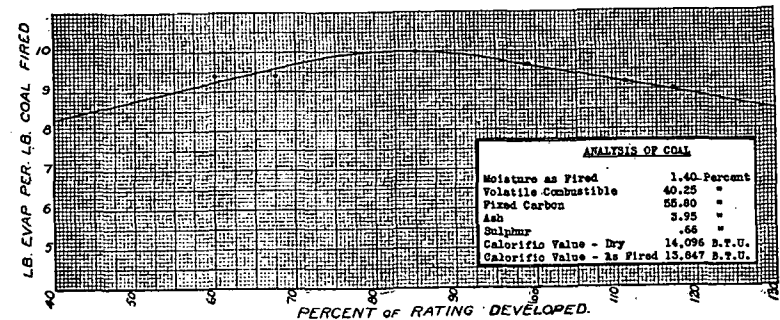
The performance curves shown illustrate the efficiency of Capitol Smokeless Boilers. Attention is called to the high volatile coal used in these tests. Capitol Smokeless Boilers burn these coals without smoke and with great economy.

400 Series Ratings and Dimensions

Size	Rating Sq. Ft.		Height Water Line Inches	Coal Capacity Cu. Ft.	Base Dimensions Inches	*Outlets	Minimum Chimney Sizes	
	Steam	Water					Diameter Inches	Height Feet
408	3300	5280	49	9.00	47x 63 1/2	2-5"	18x18	50
409	3850	6160	49	10.40	47x 71 1/2	2-5"	18x18	50
410	4400	7040	49	13.30	47x 79 3/8	3-5"	20x20	55
411	4950	7920	49	14.70	47x 87 5/8	3-5"	20x20	55
412	5500	8800	49	16.30	47x 95 3/4	3-5"	22x22	55
413	6050	9680	49	17.70	47x103 3/4	3-5"	24x24	60
414	6600	10560	49	19.25	47x111 3/4	4-5"	24x24	60

*All 400 Series Boilers have two six-inch inlets on rear of back section. Dimensions, inclusive of trimmings: Height 68 inches, Width 77 inches. Diameter of Smoke Pipe, 18 inches.

Performance Curve for No. 511 Capitol Smokeless Boiler



THE CAPITOL SMOKELESS BOILER will burn any of the bituminous coals of the United States, including the lignites of the far West—burn them smokelessly, and within the requirements of any smoke ordinance of any city of the United States.

500 Series Ratings and Dimensions

Size	Rating Sq. Ft.		Height Water Line Inches	Coal Capacity Cu. Ft.	Base Dimensions Inches	Outlets and Inlets	Minimum Chimney Sizes	
	Steam	Water					Diameter Inches	Height Feet
508	6275	10000	66	18.87	57 3/4 x 67 3/8	3-5"	24x24	60
509	7150	11400	66	23.73	57 3/4 x 77	4-5"	24x24	65
510	8025	13000	66	25.80	57 3/4 x 86 1/8	4-5"	24x28	70
511	8900	14250	66	28.59	57 3/4 x 95 1/4	4-5"	28x28	80
512	9775	15650	66	29.58	57 3/4 x 104 3/8	5-5"	28x32	85
513	10650	17050	66	34.51	57 3/4 x 113 1/2	5-5"	32x32	85
514	11525	18450	66	37.80	57 3/4 x 122 3/8	5-5"	32x32	90
515	12400	19850	66	41.09	57 3/4 x 131 3/4	6-5"	32x36	90
516	13275	21250	66	44.37	57 3/4 x 140 3/8	6-5"	36x36	90

Dimensions, inclusive of trimmings: Height 92 inches, Width 82 inches. Diameter of Smoke Pipe, 21 inches.

Thatcher Furnace Co.

131-133-135 W. 35th St.

New York

CHICAGO

341 N. Clark St.

NEWARK

42 St. Francis St.

Boilers, Ranges, Furnaces, Hot Water Supply and Garage Heaters

Thatcher "Round"
Boiler

Since 1850

In actual competitive tests with standard heaters of same rated capacity, the "Thatcher" Round Boiler proved to be the most efficient in heat transmission and length of time between firing periods.

Made in four sizes, 19, 22, 25 and 28" fire-pot. Rated capacities of from 300 to 1000 square feet for the Steam boiler and 500 to 1650 for the Hot Water boiler. The steam dome has ample space to insure dry steam. The water dome is considerably lower than in most hot water boilers; thin waterways; heavily corrugated under surface, making it unnecessary to circulate a large volume of water.

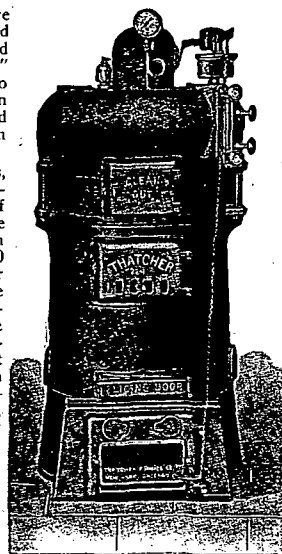
The Boiler Body. The three ports or legs extending into the fire increase heating efficiency.

The Boiler Sections. The staggered fire-travel causes the flames and hot gases to mushroom between sections.

The Base is high with ample space under the grates so that the ashpit is readily cleaned. Grates are of the revolving triangular type, easily operated and very efficient.

The Butterfly Damper Door is connected with the draft chamber door in the smoke hood by a chain through regulator arm.

The Regulator is of the disc type. Extremely sensitive.

Thatcher "Sectional"
Boiler

The Sectional Boiler is of the end feed type of square sectional boiler with an unusual amount of prime heating surface. The smoke and gases pass THREE times the length of the boiler. They come in contact with heating surface at every point. All sections are tested to eighty pounds hydrostatic pressure before leaving plant. Height of feed door allows carrying ample charge of coal resulting in fuel economy.

Grates are of heavy crown top pattern. All sections made water tight by a heavy cast iron nipple. Feed door being particularly wide affords easy access to the interior of the boiler and permits entrance of large shovel into mouth of the feed door, greatly facilitating the firing.

Castings accurately machine fitted.

Regulator is very sensitive, set to operate the drafts at a very slight steam pressure. Water tight joint. All sections are joined by a heavy cast iron nipple, lathe turned.

This boiler is conservatively rated and is the result of over seventy years of study and experience.

Johnson Service Company

Milwaukee, Wis.

BRANCHES:

BOSTON, MASS., 31 Waltham Street
BUFFALO, N. Y., 2 Erie County Bank Bldg.
CHICAGO, ILL., 177 North Dearborn Street
CINCINNATI, OHIO, 405 Gwynne Building
CLEVELAND, OHIO, 2028 East 22nd Street
DENVER, COLO., 517 Boston Building
DES MOINES, IOWA, 210 Masonic Temple
DETROIT, MICH., 42 Montcalm Street, West
INDIANAPOLIS, IND., 111 Pembroke Arcade
KANSAS CITY, MO., 411 East Tenth Street
MILWAUKEE, WIS., 149 Michigan Street
LOS ANGELES, CAL., 605 Van Nuys Bldg.

MINNEAPOLIS, MINN., 308 Third Avenue, South
NEW YORK, N. Y., 18 East Twenty-eighth St.
OMAHA, NEB., 609 Paxton Building
PHILADELPHIA, PA., 1521 Sansom Street
PITTSBURGH, PA., Century Building
PORTLAND, ORE., 404 Failing Building
SALT LAKE CITY, UTAH, 301 Templeton Building
SAN FRANCISCO, CAL., 314 Rialto Building
SEATTLE, WASH., 452 Colman Building
ST. LOUIS, MO., 14 North Twelfth Street

CANADIAN REPRESENTATIVE:

Johnson Temperature Regulating Company of Canada, Limited

OFFICES:

CALGARY, ALTA, 605 Second Street, West
VANCOUVER, B. C., 550-6th Avenue, West

TORONTO, ONT., 118 Adelaide Street, West
WINNIPEG, MAN., 259 Stanley Street
MONTREAL, QUE., 284 Beaver Hall Hill

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.

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 and Rubber Diaphragm Valves.

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 Positive Acting Metal Diaphragm Thermostat

The only thermostat on the market provided with positive snap action for closing and opening the radiator valve quickly, positively and fully, which is necessary with steam heat.

Indicator and Cut-off

It is the only thermostat having an indicator which will show at a glance whether the thermostat has the heat turned on or off. A cut-off is provided for shutting the heat off permanently when desired.

Johnson Graduated Acting Thermostat

For controlling the temperature of rooms heated by steam, hot blast or hot air furnaces. It controls a mixing damper located at the plenum chamber. The damper, which is furnished, together with the thermostat, etc., is operated by a diaphragm damper



Model Positive Metal Diaphragm Thermostat

motor, connected with the thermostat in such a way that the damper blades will automatically assume the correct intermediate position necessary to deliver the right mixture of hot and tempered air to the room and to maintain a constant and proper temperature therein.

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.

The P type is a pressed metal cover, very finely finished but not as ornamental and artistic as the R cover, and used more generally in schools, office buildings, hospitals and places where simple and neat design is desired rather than artistic and ornamental.

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.

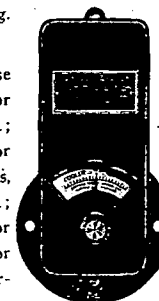


Model R. I. Cover
 4 1/4" x 2" x 1 1/4" deep

This thermostat is made either positive or graduated acting.

Applications

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.



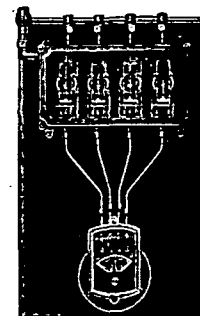
Pneumatic Insertion Thermostat

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 lbs. 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° and to minimum space of 2 1/4".

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 3-point multiple thermostat shown will operate 3 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 boiler heating plants by its control of the boiler draft doors.

Humidity Control

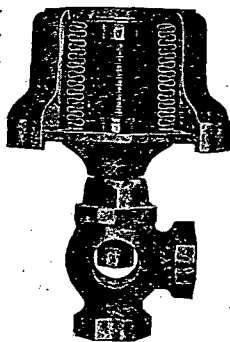
The supplying of moisture to the heated air in buildings and the automatic control of the percentage of moisture in this air are recognized by authorities to be as important as maintaining proper temperatures.

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.

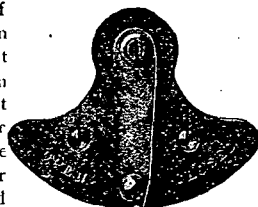
"Sylphon" Metal Diaphragm Valves

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, registers in wall boxes "Sylphon" Metal Diaphragm Valve where excessive heat would destroy rubber diaphragms.



"Sylphon" Metal Diaphragm Valve

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.

Time Valve Control

Simple device for automatically and periodically opening and closing a diaphragm valve.

Has many applications, such as periodically flushing of toilets, etc. Being simpler and more powerful in action, it is much superior to float tanks. Eight-day clock valve mechanism operates diaphragm valve on water supply by means of compressed air. Valve may be operated from 1 to 4 times per hour and for periods of 15 seconds to 5 minutes.

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—Specify Johnson Metal Diaphragm Model Thermostat, size, 4½" by 2" by 1"; 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° 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.

H. S. B. W.-Cochrane Corporation

17th Street below Allegheny Ave.

Philadelphia, Pa.

Also Offices in Atlanta, Baltimore, Birmingham, Boston, Chicago, Cincinnati, Cleveland, Dallas, Denver, Detroit, Hazleton, Houston, Indianapolis, Kansas City, Los Angeles, Minneapolis, New Orleans, New York, Pittsburgh, Richmond, Rochester, St. Louis, Salt Lake City, San Francisco, Seattle, Syracuse, Tucson, Toronto, Montreal, Halifax, Canada.

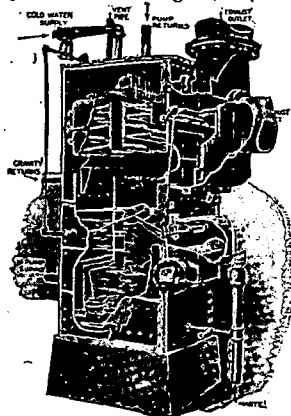
Feed Water Heaters, V-notch Meters and Metering Heaters, De-Aerating Heaters, Hot and Cold Process Water Softeners, Steam and Oil Separators, Flow Meters, Multiport Back Pressure Valves, Multiport Drainers.

"To Economize—Cochranize"

Improving the economy of steam plants by the better utilization of exhaust steam and the heating, metering, softening, and de-aeration of water has constituted the work of the Cochrane Engineering staff for more than thirty years. Cochrane apparatus particularly adaptable to heating systems includes the following:

Cochrane Feed Water Heaters

The Cochrane Open Feed Water Heater utilizes exhaust steam to heat water up to 210°F. or higher, depending upon the back pressure carried. The exhaust steam passes through an oil separator before entering the heater, all oil and grease being thereby effectively removed before the steam comes into contact with the water. Where the surplus of exhaust steam not consumed in the heater is to be used in heating or drying coils or processes, the separator can be made large enough to purify the entire amount of steam and valves can be provided, as in the Cochrane Steam-stack and Cut-out Valve Heater, by means of which the body of the heater can be isolated while the separator remains in service. The heater water storage space serves as a return tank or hot well for condensate and can be made extra large to provide extra storage if desired. The drips from the separator and any overflow from the heater are discharged through a trap. The shell is constructed to stand pressures up to ten pounds gauge.



Steam-stack and Cut-out Valve Heater

Cochrane De-Aerating Heaters

Where entire removal of free oxygen from the water is desired in order to prevent corrosion in pipe lines, economizers and boilers, a special type of Cochrane heater is supplied. With this apparatus the following benefits are obtained:

1. Oxygen-free water at any temperature above 120°F. De-aeration can be secured with only a small amount of steam.
2. The water is heated to the maximum temperature obtainable with the amount of exhaust steam available.
3. Turbines, engines or pumps receive the benefit of a vacuum corresponding to the temperature to which the water is heated. Units not suitable for vacuum operation can exhaust at atmospheric pressure.
4. Apparatus can be installed to operate at first under atmospheric pressure, delivering water at 212°F., and subsequently can be easily converted if it is desired to de-aerate the water while heating it to as low a temperature, as 140°F.
5. The apparatus is simple and compact and can be installed where head room is limited. It is recommended for hot water heating systems, as well as for hot-water service and boiler feeding.

Steam and Oil Separators

Cochrane steam separators stop slugs of water brought over from the boiler or due to condensation in the steam line. Some moisture is always present in steam, unless super-heated, and sometimes even then. If this moisture is allowed to enter engine cylinders it will wash away the cylinder oil, or in turbines cause erosion of the blades.

Cochrane oil separators remove oil and grease from exhaust steam before it is used in heating or drying coils or processes. Exhaust steam purified of oil by passing through a Cochrane Oil Separator is just as good as live steam at the same pressure for cooking, operating low pressure turbines, operating ice machines, heating, drying or in calendering rolls, etc. The condensed returns will be free of oil and can be brought back and used over and over again for boiler feeding. Over 16,000,000 horsepower of boilers are being fed satisfactorily with water condensed from steam purified by Cochrane Oil Separators.

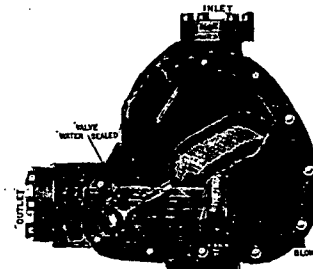
Cochrane Separators are made in all sizes, for vertical, horizontal and angle pipes.



Cochrane Vertical Separator

Cochrane Multiport Drainer

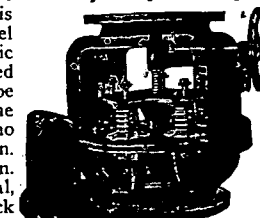
The Cochrane Multiport Drainer removes condensate or drips from heating or drying coils, radiators, steam rolls or drums, steam and oil separators, etc. The hollow cylindrical valve is absolutely balanced and has large ports, giving large capacity with low operating pressure. It never leaves its seat and is self-cleaning and always water sealed. The complication of pilot valves, springs and links is avoided. Upon taking off the cover the float and attached valve can at once be lifted out. The valve seat is also easily removable. There are no stuffing boxes or packings. It cannot become air bound.



Multiport Drainer

Cochrane Multiport Back Pressure Valve

The Cochrane Multiport Safety Exhaust Outlet Valve, or back pressure valve, is used in connection with exhaust steam heating or drying system, open feed water heaters, exhaust steam turbines, evaporators and, in a slightly modified form, with surface and jet condensers. It has a number of small disks instead of one large disk, hence there is no possibility of failure by sticking. A large exhaust area is obtained in moderate size, as there is 100% greater disk area than in a single-disk valve. Only a small lift is required and the disks are light, hence there is no hammering of the seats. Each disk is cushioned by an individual dash pot, hence no rattle. There are no heavy moving parts, as the disks are held to their seats by independent springs having little inertia. The tension on all springs is regulated from outside the housing by a hand wheel or from a distance by means of rods, chain or electric motor. The motion of the pressure plate is limited so that a predetermined back pressure cannot be exceeded. There are no moving parts outside the casing directly connected to the disks, hence no possibility of obstruction, jamming or tying down. The disks are easily accessible for grinding in. Cochrane Multiport Valves are built for horizontal, vertical and angle pipes and for vacuum and back pressure service.



Cochrane Multiport Valve

Drying Systems, Inc.

11-17 So. Desplaines St.,

Chicago

CLEVELAND

LOS ANGELES

Varnish Drying, Air Conditioning and High Temperature Baking Equipment

Drying Systems, Inc., specializes in **Drying Problems** and our equipments have been applied with conspicuous success to the drying of Varnish and Undercoatings, Low and High Temperature Enamels, Dimensioned and Core Stock, Veneered Panels, Coated Cloth and Leather, and many other products. We design and install air conditioning apparatus for Finishing Rooms.

The rapid drying of the various **siccative coatings** applied to furniture, cabinets, pianos, automobile bodies, chassis, wheels and, in fact, everything that requires a coating, is of great importance to the manufacturer when orders, large or small, must be delivered on a planned schedule without delay.

The artificial hastening of the drying must, however, be so effected that the coating will be thoroughly and uniformly dried throughout its entire depth. Heated air, alone, causes surface-drying and certain chemical and physical changes which impair the quality of the finish. Surface-drying impedes the completion of the drying by covering the coating with an almost impervious surface film through which the volatiles escape with great difficulty, and which retards oxi-

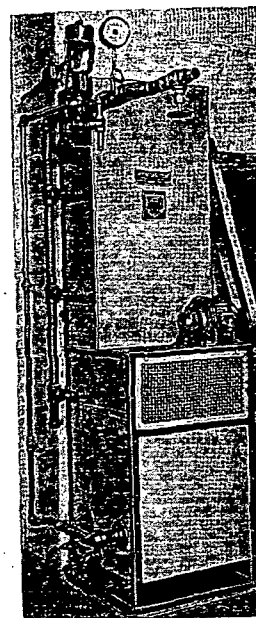
dation, an essential factor in the process of hardening. The vital element in the drying of all siccative coatings is humidity. Moisture in the air functions to prevent surface-drying and detrimental changes. With adequate circulation of properly humidified and heated air drying becomes a perfected and rapid process, insuring a coating of finest quality, both in appearance and in durability.

And, of even greater importance, conditioned air drying insures a positive and unvarying time schedule, each coat drying in the same time all of the time, regardless of outdoor weather. This permits the establishment of an efficient drying routine, on an exact schedule, greatly increasing production and minimizing costs.

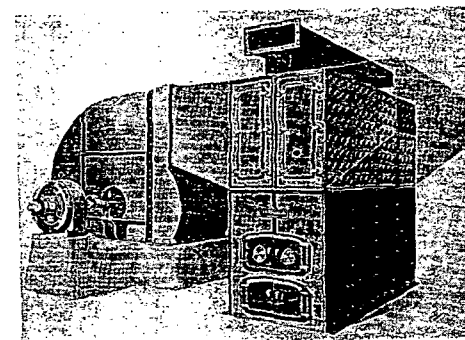
Our broad experience in drying and conditioning, gained through hundreds of successful installations, is at the disposal of our clients and we invite correspondence with reference to such problems.

We manufacture several types of equipment each adapted to specific requirements.

The Drying Unit



The Drying Unit consists of a substantially constructed sheet metal casing in which are compactly assembled a multi-blade fan, radiators (for either high or low pressure steam), an air washer-humidifier, automatic temperature and humidity control, steam supply and return, water supply and drain, and the necessary valves, all ready for quick connection. The Unit is manufactured in three sizes and can be installed in connection with any of the old-style dry rooms, without radical changes in construction. With each Drying Unit we furnish a properly designed system of supply and vent ducts. These Units will supply dry rooms up to 800 sq. ft. of floor-space and are in use in many plants for drying varnish, undercoatings, dimensioned and glued-up stock, etc.



The Harrison Aertube Heater

The Harrison Aertube Heater is a complete plant of the direct-fired indirect type, utilizing any of the ordinary fuels, but preferably 11" Beaumont oil. This Heater is used for heating air in large volumes to temperatures up to 1000°F., avoiding contamination of the air with the products of combustion. The heat is transferred, by convection, from the fuel directly to the air, through tubes of special metal, and this Heater is exceptionally economical and effective, as well as entirely safe, for High Temperature Baking of Enamels, Drying and Processing.

The Greeff System of Drying and Conditioning comprises the Greeff Static Air Washer-Humidifier, Fan, Heaters, Automatic Temperature and Humidity Control. The equipment is placed close to the dry room so series of dry rooms and the conditioned air is supplied to the dry room through carefully designed ducts, insuring uniform circulation throughout the enclosure.



The Greeff System of Drying
Descriptive Bulletins will be sent upon request

A report of our installation at the plant of Globe-Wernicke Co. Cincinnati, shows that the annual saving in floor-space and interest on capital tied up in unfinished material, is \$16,000.00, or 225% on the investment.

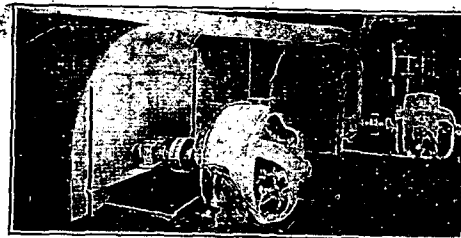


Sprague Ventilating Equipments



From the early efforts at ventilating large buildings twenty years ago to the present day, the Sprague Electric Works has been co-operating with architects and engineers in the making of practical ventilating equipment. Resulting installations are now found in many well known hotels, office buildings and department stores, where they have distinguished themselves for exceptional reliability and economical operation. Three typical pieces of modern Sprague equipment are illustrated below:

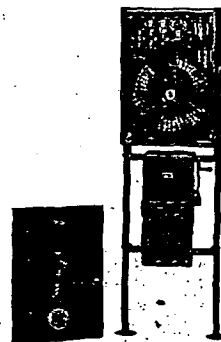
Sprague Electric controllers for varying speed A. C. fan motors with magnetic main line contactor, under-voltage and overload protection, large number of speed steps, and complete enclosure of live parts are the ideal equipment for architects and engineers to specify when the circuit is alternating current.



The Sprague type LC D. C. slow speed motor is especially adapted for driving ventilating fans. The steel field, laminated poles, commutating poles, substantial end-brackets, correct oiling systems, ideal electrical design, well built commutators, rigidly supported brush holders—these insure a long life, lowest possible current consumption and the smallest maintenance charges.

Sprague Electric remote controlled push button operated, automatic self-starting speed regulators (D. C. here illustrated) for either A. C. or D. C. motors are being used to an increasing extent. These controllers are simple in operation, with negligible up-keep expense, and control the motor, at any desired predetermined speed, from a remote point. They are destined to be adopted generally for all classes of work to supplement manually operated controllers as the standard for the future.

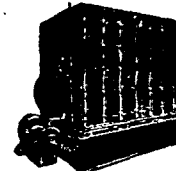
We shall be glad to co-operate with Architects and Engineers in laying out their Ventilating Equipments.



American Blower Company

Detroit, Mich.

Mfgs. of Heating, Ventilating, Cooling, Purifying, Humidifying, Drying, Mechanical Draft and Blast Equipment; Vertical Self-Oiling Steam Engines, Steam Traps; Fans and Blowers for All Purposes.



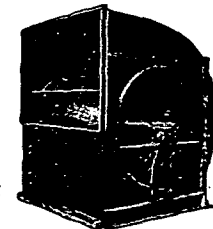
"Sirocco"
Air Washer

System of Purifying, Cooling and Humidifying

For Purifying and Humidifying air in Schools, other Public and Semi-Public Buildings.

For Humidifying and Cooling air in Textile Mills, Food and Confectionery Plants, Printing Houses, and other Industrial Plants.

For Dehumidifying and Cooling in Candy Factories, Bakeries, Photo Film Drying Rooms, Blast Furnaces, Electric Generators, etc.



Multiblade Fans and Blowers

For Heating, Ventilating and Cooling in Public, Office, Industrial and Educational Buildings.

For Drying and Mechanical Draft.

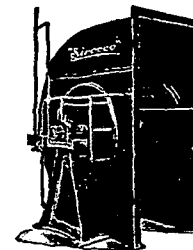
Sirocco Multiblade Fans will handle more air, consuming less power than the ordinary steel plate fan having twice the wheel diameter.

ABC Air Washing and Cooling Fan

The ABC Air Washing and Cooling Fan combined does the work of the centrifugal fan, the air washer and the pump required for circulating water in a separate washer and does this with less power and with material reductions in maintenance and attendant costs. It is an automatic, highly efficient and durable unit that adequately provides for purification, humidification and cooling.

The ABC Air Washing and Cooling Fan is used in Schools, Theatres, Clubs, Churches, Auditoriums, Stores and Industrial Buildings, and insures good air conditions, bodily comfort and increased working capacity.

It requires a minimum of attention and occupies small floor space. A special bulletin descriptive of this fan will be sent upon request.



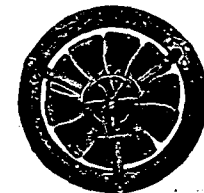
"Ventura" Disc Ventilating Fan

For delivering large volumes of air at low pressure or against small resistance.

Low price—small power consumption and inexpensive to install.

For ventilating rooms and buildings—Ventura, motor driven, ventilating fans, 650 C. F. M. to 17,500 C. F. M.

For ventilating small mines or at any mine where a disc fan can be used—engine or motor driven—from 12,000 C. F. M. to 100,000 C. F. M. resistance not to exceed 1" W. G.



Buffalo Forge Company

Carrier Air Conditioning Company of America

Buffalo, New York

BRANCHES:

NEW YORK, 39-41 Cortlandt St.
PHILADELPHIA, 1303 Land Title Bldg.
BOSTON, 88 Broad St.
CLEVELAND, 368 Rockefeller Bldg.
PITTSBURGH, 917 Union Arcade
DETROIT, 1772 W. Lafayette Blvd.
CHICAGO, 562 W. Washington Blvd.

WASHINGTON, Washington Loan & Tr. Bldg.
ST. LOUIS, 515 Chemical Bldg.
CINCINNATI, 607 Mercantile Library Bldg.
MINNEAPOLIS, 120 South Ninth St.
DENVER, 1718 California St.
LOS ANGELES, 636 H. W. Hellman Bldg.
INDIANAPOLIS, 2439 College Ave.

PORTLAND, ORE., Power Equipment Co.

CANADIAN BRANCH, Canadian Blower and Forge Co., Kitchener, Ontario

Offices in All Principal Cities of Canada

"BUFFALO" PRODUCTS

Conoidal Multiblade Fans

Carrier Air Washers

Pipe Coil Heaters

Ventilating Sets

Disk Fans

Humidifiers

Dehumidifiers

Generator Coolers

Gas Scrubbers

Stoker Fans

Induced Draft Fans

Planing Mill Exhaust Fans

Dust Collectors

Pressure Blowers

Sintering Fans

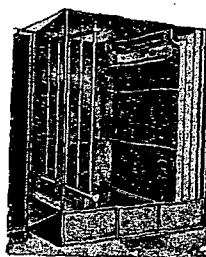
Drying Apparatus

Spray Nozzles

Forge Shop Equipment



Direct-Connected Fan



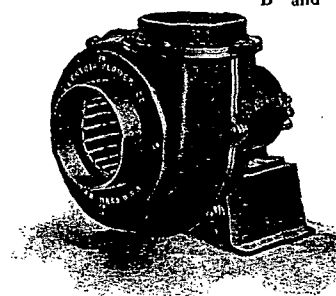
Carrier Air Washer with Side Casing Removed.

We have catalogs covering most of the above products individually. They contain not only specifications and performance tables, but also a wealth of engineering data on the application of such equipment.

Individual catalogs or complete binder furnished on request.

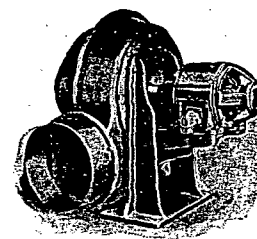
Electric Blower Company

352 Atlantic Avenue
Boston 9, Mass., U. S. A.



"B" and "C" Ventilating Sets

The "B" Ventilating Set, 4" inlet, 4" outlet, convertible to any discharge, equipped with a ring oil bearing variable speed motor, is designed especially for ventilating toilet seats that are provided with an outside vent connection.



No. 4 and 7 Exhausters

The "B" size will handle from 1 to 4 closets, and can be installed for automatic operation when seat is occupied.

Intended to be installed in the attic with pipes from each closet connected to inlet, and outlet discharging into the outside vent pipe or chimney.

With attention once a year, it will last indefinitely.

No. of Blower	Height	Watts Consumed	Cub. Ft. per Minute	Water Col. Pressure	O. D. Inlet	O. D. Outlet	Speed of Fan	Weight lbs.	Net Price
"B" Ventilating set.	in.	100	225	1 1/2	in.	in.	3600	45	\$50
"C" Ventilating set.	13	85	400	1 1/2	5	5	2400	50	60
18 in.	18	225	485	2	6	5	1750	95	90
No. 3 Special	22	350	650	2 1/2	6	5	1750	135	
No. 4 Exhauster	21	300	1450	1	8	8	1150	165	150
No. 4 Exhauster	21	600	2175	2	8	8	1750	185	
No. 5 Exhauster	29		2500	3	9	9	1750	280	
No. 7 Exhauster	33	550	2500	2	12	12	1150	390	
No. 7 Exhauster	33	1100	3750	4	12	12	1700	425	

"Marvel" Blowers

For Gas and Oil Combustion

The No. 0-R Blowers are designed especially for use on gas doughnut cookers and candy kettles besides blow pipes and soldering outfits. 2 to 4 oz. pressure is ample for gas combustion.

Our No. 1-R Blowers with our special wound split phase induction motors for use with our Patented Protective Device are superior outfits for forced draft on gas and oil burners and fine coal for house heating.

These ring oil bearing motors have very large oil wells (also the motors on the other type "R" Blowers), and used with the Protective Device, will operate indefinitely under conditions where standard wound motors would fail.

Sizes No. 2-R, No. 3-R, No. 3 Special and No. 4-R can be equipped with high speed motors to give up to 10 oz. air pressure with corresponding increase in Volume

No. of Blower	Motor	Height	H. P. Motor	Cub. Ft. free air per HOUR	Water Col. Pressure	O. D. Inlet	O. D. Outlet	Speed of Fan	Weight lbs.	Net Price
No. 0-R	Brush Type	12	1-15	3000	6	2 1/2	2 1/2	4000	35	\$50
No. 0-R	Induction	12	1-15	3000	3			3600	35	50
No. 1-R	Induction	12	1-15	4500	3	2 1/2	3	3600	40	50
No. 2-R	Induction	20	1-6	8000	3 1/2	3 1/2	3	1600	110	95
No. 3-R	Induction	22	1-4	11000	3 1/2	3 1/2	3 1/2	1800	130	100
No. 4-R	Induction	14	1-4	5500	2 1/2	2 1/2	3	3600	65	80
No. R-4	Induction	26	1-2	45000	6	6	6	1800	230	150

Hersh Brothers Company

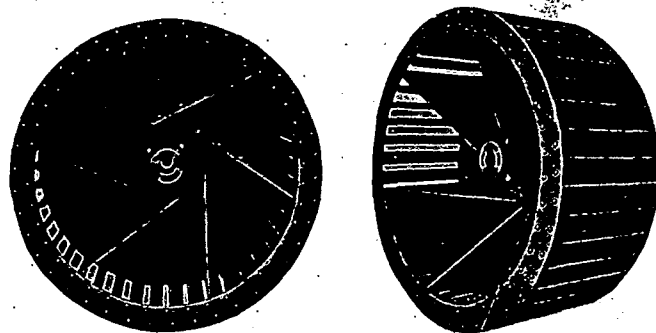
Allentown, Penna.

149 Broadway, N. Y.

LEHIGH

131 State St., Boston

Fans, Blowers, Air Washers, Ventilators, Dust Collectors



Lehigh Multiblade Fans—Type "M"—For Use in Heating and Ventilating

This type of fan is designed particularly for use in connection with heating and ventilating systems in public and industrial buildings where large volumes of air are handled at comparatively low pressures. It is proportioned to give low velocities of air throughout with the least resistance both at the entrance and at the discharge.

The special construction of this type of wheel combines in one the desirable qualities of the older steel plate fan wheel with the large capacity and efficient operation of the Multiblade Type. This wheel requires no stay-rods to keep it in shape under any speed. The strength and rigidity of construction can be readily ascertained from examination of the radial blades which run to the hub of the wheel, so placed in order to give the greatest strength in the direction of rotation. The strains on this

wheel are those of tension, in which all metal is strongest, rather than shear, in which it is weakest. No wobbling side thrusts occur with this construction. The curvature of the Multiblades does not restrict the area of discharge and therefore the capacity of the wheel.

The housing, being rigidly braced with angle iron and the inlet and outlet with tee iron punched for sheet metal connection, is free from vibration under the highest speeds and pressures.

The bearings are of unusual quality (ball and socket type) with double ring oiling and best babbit. They are self-aligning in all directions. This prevents the shaft from becoming bound.

The shaft is constructed of the best grade of DRAWN STEEL containing from 30 to 40% carbon.

LEHIGH MULTIBLADE FANS—TYPE "M"

FOR USE IN HEATING AND VENTILATING

RECOMMENDED OPERATING CONDITIONS, 70° F., 29.92" BAR

Dia. Wheel, Inches	Area Outlet, Sq. Ft.	14" STATIC PR.			14" STATIC PR.			14" STATIC PR.			14" STATIC PR.			14" STATIC PR.		
		Total Pres.	Outlet Vel.	Per. Speed.	Total Pres.	Outlet Vel.	Per. Speed.	Total Pres.	Outlet Vel.	Per. Speed.	Total Pres.	Outlet Vel.	Per. Speed.	Total Pres.	Outlet Vel.	Per. Speed.
15	1.24	1,610	409	18	1,735	497	25	1,860	546	34	1,985	603	44	2,110	656	54
18	1.78	2,320	341	28	2,500	415	36	2,680	455	48	2,850	503	62	3,030	547	78
21	2.43	3,160	292	34	3,400	355	48	3,650	390	65	3,900	431	84	4,130	469	1.1
24	3.17	4,120	256	44	4,500	311	63	4,750	341	84	5,075	377	1.1	5,400	410	1.4
27	4.02	5,150	227	55	5,620	276	78	6,020	303	1.06	6,430	335	1.37	6,830	364	1.7
30	4.96	6,450	209	68	6,950	249	97	7,450	273	1.3	7,960	303	1.7	8,430	328	2.1
33	6.0	7,800	189	81	8,400	226	1.16	9,000	248	1.56	9,600	274	2.1	10,200	298	2.6
36	7.25	9,280	171	96	10,000	207	1.37	10,700	227	1.85	11,400	252	2.4	12,150	273	3.0
42	9.72	12,600	146	1.3	13,600	178	1.85	14,600	195	2.5	15,500	216	3.25	16,500	234	4.0
48	12.7	16,500	128	1.7	17,750	156	2.4	19,000	170	3.2	20,300	188	4.2	21,500	205	5.3
54	16.1	20,850	114	2.1	22,500	135	3.0	24,100	151	4.0	25,700	168	5.3	27,100	182	6.5
60	19.8	25,750	103	2.6	27,800	124	3.7	29,700	137	5.0	31,700	151	6.4	33,700	164	8.0
66	24.0	31,200	93	3.1	33,600	113	4.5	36,000	124	6.0	38,400	137	7.8	40,800	149	9.7
72	28.6	37,700	86	3.6	40,000	104	5.2	42,800	114	7.0	45,700	126	9.1	48,500	137	11.3
78	33.5	43,600	79	4.2	47,000	96	6.1	50,250	105	8.1	53,700	116	10.6	57,000	126	13.2
84	38.9	50,600	73	4.8	54,400	89	7.0	58,300	98	9.4	62,300	108	12.2	66,200	117	15.2
90	44.6	58,000	65	5.5	62,500	83	7.9	67,000	91	10.6	71,450	101	13.8	76,000	109	17.2
96	50.8	66,000	64	6.2	71,200	78	8.9	76,200	86	11.9	81,200	95	15.5	86,400	103	19.3
102	57.3	74,500	61	7.0	80,250	73	10.0	86,000	81	13.4	91,700	89	17.5	97,400	97	21.8
108	64.3	83,500	57	7.8	90,000	69	11.2	96,500	76	15.1	102,800	84	19.6	109,200	91	24.4
120	79.3	103,000	52	9.7	111,000	63	13.8	119,000	69	18.6	127,000	76	24.2	135,000	82	30.0

Dia. Wheel, Inches	Area Outlet, Sq. Ft.	14" STATIC PR.			14" STATIC PR.			14" STATIC PR.			14" STATIC PR.			14" STATIC PR.		
		Total Pres.	Outlet Vel.	Per. Speed.	Total Pres.	Outlet Vel.	Per. Speed.	Total Pres.	Outlet Vel.	Per. Speed.	Total Pres.	Outlet Vel.	Per. Speed.	Total Pres.	Outlet Vel.	Per. Speed.
15	1.24	2,230	751	73	2,480	838	1.0	2,850	922	1.5	3,100	1000	1.85	3,350	1073	2.4
18	1.78	3,210	625	1.1	3,540	668	1.5	4,100	768	2.1	4,460	832	2.6	4,830	895	3.5
21	2.43	4,370	536	1.4	4,850	600	8.0	5,380	659	2.8	6,070	714	3.5	6,550	768	4.6
24	3.17	5,710	469	1.9	6,350	524	2.6	7,200	576	3.6	7,850	624	4.6	8,580	671	6.0
27	4.02	7,240	417	2.3	8,040	466	3.2	9,250	513	4.6	10,000	555	5.8	10,850	597	7.5
30	4.96	8,930	375	2.9	9,900	419	4.0	11,400	461	5.6	12,400	500	7.1	13,400	537	9.3
33	6.0	10,800	341	3.4	12,000	381	4.8	13,800	419	6.7	15,000	454	8.5	16,200	488	11.2
36	7.25	12,850	313	4.1	14,300	349	5.6	16,450	384	8.0	17,850	416	10.1	19,300	447	13.3
42	9.72	17,500	268	5.5	19,400	300	7.6	22,400	330	10.7	24,500	357	13.6	26,500	384	17.8
48	12.7	22,900	235	7.7	25,400	262	9.8	29,200	288	13.8	31,700	312	17.6	34,300	336	23.0
54	16.1	28,900	208	9.9	32,000	233	12.5	36,900	256	17.3	40,200	278	22.0	43,300	299	28.8
60	19.8	35,700	188	10.8	39,800	210	15.0	45,600	231	21.2	49,500	250	26.9	53,500	269	35.3
66	24.0	43,150	171	13.0	48,000	191	18.0	55,200	210	25.4	60,000	227	32.3	64,800	244	42.3
72	28.6	51,400	153	15.3	57,200	172	21.2	65,700	192	30.0	71,500	208	38.1	77,100	224	50.0
78	33.5	60,400	145	17.6	67,500	154	24.2	77,000	178	34.9	83,700	192	44.3	90,500	207	58.0
84	38.9	70,000	134	20.5	77,700	150	28.3	89,500	165	40.0	97,200	179	50.8	105,000	192	66.7
90	44.6	80,400	125	23.2	89,400	140	32.3	103,000	154	45.5	111,600	167	58.0	120,600	179	76.0
96	50.8	91,400	118	26.2	101,500	131	36.3	116,800	145	51.3	127,000	156	65.2	137,000	168	85.5
102	57.3	103,000	107	29.4	114,600	124	40.7	132,000	135	57.6	143,000	147	73.3	155,000	158	96.2
108	64.3	115,700	104	33.0	128,500	117	45.8	147,600	129	64.7	160,500	139	82.2	173,800	149	108.0
120	79.3	145,000	94	40.7	159,000	105	56.5	182,500	116	79.8	198,300	125	101.5	214,000	135	133.0

Massachusetts Blower Company

General Offices and Factory

Watertown, Mass.

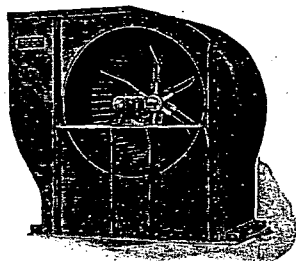
Offices In All Principal Cities

Heating & Ventilating Apparatus, Fans, Blowers, Exhausters, Mechanical Draft Ventilators, Air Washers, Heaters, Etc.

Forced or Induced Draft makes it possible to burn low grade fuels. Increased economy of present boilers or the addition of boilers may also be accomplished without change in the present chimney.

Fan systems used in connection with drying of commercial products permit continued operation in all seasons and weather. Reduced costs and increased production mean a continual return from a small outlay.

Heating and Ventilation of Public Buildings, Schools, Theatres, Factories, Tunnels, etc., require fans of specific types. We make a full line of Fans and Blowers to suit such installations.



Squirrel Cage Fans. Wheels or runners are composed of shallow blades, permitting a large inlet area. Small size and great capacity in small space, make these fans ideal for Schools, Public Buildings, Factories, etc. They are suitable for all classes of work done formerly by the Steel Plate Fan. They are not, however, designed for moving materials.

Steel Plate Fans are built to suit requirements for Ventilation, Mechanical Draft or for Conveying purposes. The special kinds of manufacture which can

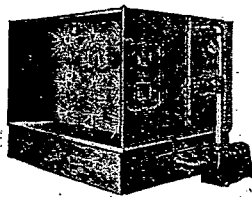
be aided by using a fan for drying, cooling, conveying, etc., are innumerable.

Portable Service Sets, suitable for Ventilating Moving Picture Booths, Telephone Booths, Laboratories, etc., are built in sizes ranging from 100 c.f.m. to 2,000 c.f.m. capacity. Adjustable for different discharges, this is an ideal type of fan for handling small volumes.



Propeller and Disc Fans are designed to handle large volumes of air under low pressure and are arranged for either pulley drive or direct connection to motors. For handling acid fumes the blades are constructed of acid-resisting material.

Massachusetts Heaters of return bend type or mitre type are built in various sizes to suit requirements, both for hot water and for high pressure steam. We have heaters working under 400 pounds pressure.



Massachusetts Air Washers are built in various sizes to meet requirements for efficient cleaning, cooling, humidifying and de-humidifying of air.

B. F. Sturtevant Company

Hyde Park, Boston, Mass.



Atlanta, Ga.
Boston, Mass.
Buffalo, N. Y.
Chicago, Ill.
Cincinnati, O.
Cleveland, O.
Dallas, Tex.
Detroit, Mich.
Hartford, Conn.
Kansas City, Mo.
Los Angeles, Cal.

CANADIAN OFFICES:
Galt, Ontario
Montreal, Que.
Toronto, Ontario

Minneapolis, Minn.
New York, N. Y.
Omaha, Neb.
Philadelphia, Pa.
Pittsburgh, Pa.
Portland, Ore.
Rochester, N. Y.
St. Louis, Mo.
Salt Lake City, Utah
San Francisco, Cal.
Seattle, Wash.
Washington, D. C.

PRODUCTS

Heating and Ventilating Equipment

Multivane Volume Blowers and Exhausters; Propeller and Disc Type Volume Exhaust Fans; Heaters; Air Washers; Engines and D. C. Motors; Galvanized Duct Work; Portable Ventilating Sets; Autoforce Ventilators.

Power House Equipment

Fuel Economizers; Mechanical Draft Apparatus; Turbine and Steam Engine Generator Sets; Gasoline Electric Generator Sets; Generator Cooling; Steam Engines; Steam Turbines; Transmission Gears.

Industrial Equipment

High Pressure, Medium Pressure and Low Pressure Blowers; Volume Blowers; Planing Mill Exhausters; Cupola Blowers; Gas Blowers and Boosters; Gas Exhausters; Forges and Forge Blowers; Acid Proof Fans; Pneumatic Collecting and Conveying Systems; Steam Exhaust Heads.

Air Conditioning Equipment

Paper, Glue, Wood and Leather Drying, Vapor Absorption Systems; Air Washing, Humidifying and Dust Removing Systems; Dehumidifying Systems.

Vacuum Cleaning Equipment

Stationary Plants for Home and Industrial Use; Portable Vacuum Cleaners of all sizes for all work.

ENGINEERING SERVICE

As each installation is unique, it is usually necessary that an engineer analyze the conditions before making recommendations. The engineering staff of the B. F. Sturtevant Company has been trained to analyze conditions and to properly apply our apparatus accordingly. Consult them, they are at your service without obligation.

PUBLICATIONS

The STURTEVANT line is so varied that a comprehensive presentation in one publication is undesirable. We have, therefore, issued a special bulletin on each particular line, covering the mechanical details.

CATALOGS

Air Conditioning

- No. 226 Air Washers—Types H. and C.
- 225 Air Washers—Type S.
- 23 Washers—Canadian
- Climate Doctors
- 278 Air Conditioning
- 246 Generator Cooling

Drying

- No. 254 High Humidity Lumber Dry Kiln
- 243 Paper Drying
- 1052 Vegetable Drying
- 273 Veneer Kilns
- 282 High Humidity Dry Kiln
- 289 Low Temperature Forced Circulation Hosiery Dryer

Heating and Ventilating

- No. 283 Autoforce Ventilators
- 230 Heaters
- 215 Heating and Ventilating Treatise
- 1015 Heating and Ventilating Book, Complete. Installations
- 1014 Heating and Ventilating Government Buildings
- 227 Heating and Ventilating Layouts—Blue print Books
- 1013 Heating and Ventilating Public Buildings
- 1012 Heating and Ventilating Schools
- 271 Multivane Fans, Design 3
- 237 Ready-to-Run Ventilating Sets
- 279 Disc and Propeller Fans
- 290 Silentvane Fan

Mechanical Draft

- No. 236 Forced Draft Fans
- 276 Turbo-Undergrate Blowers, Design 3
- 285 V.D.-7 Turbo Blower, Instruction Book
- 286 V.D.-7 Turbo Blower
- 288 Forced and Induced Draft with Mechanical Stokers

Pneumatic Collecting and Conveying Systems

- No. 262 Granite Dust Removal Systems
- 245 Cotton Fans, Design 7
- 234 Steel Plate Blowers and Exhausters
- 252 Steel Plate Fan Performance Chart
- 291 Collecting and Conveying

Power Apparatus

- No. 150 Sturtevant Fuel Economizers
- 222 Fuel Economizers in Paper Mills
- 255 Gasoline Electric Generating Sets
- 239 Steam Engine Generating Sets
- 256 Steam Turbines
- 256 Steam Turbine Generating Sets
- 264 Electrical Apparatus
- 263 V.S.-7 and 8 Engines Instruction Book
- 268 Marine Gasoline Engine
- 274 Turbo Transmissions
- 275 Gear Transmissions
- 284 Polyphase Motors

AMERICAN RADIATOR COMPANY

104 West 42nd St.,
New York

816 So. Michigan Ave.,
Chicago

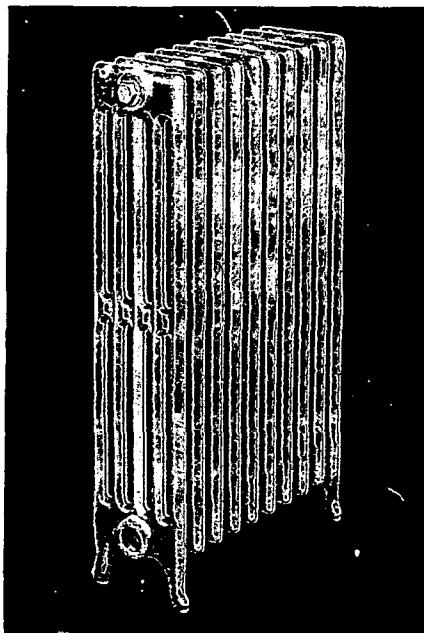
Ideal Boilers, American Radiators, Heating and Vacuum Cleaning Equipments

We present sample pages taken from various catalogs issued by us. The pages selected illustrate a few of our new products, and in part suggest the efforts our Company is putting forth to meet the demands of Engineers for utmost refinement in heating devices.

Catalogs containing valuable data for Engineers are being constantly issued or supplemented, such as the "Ideal Fitter" catalog (384 pages), Vento Data Book for Engineers (48 pages), American Wall Radiator Installation Book (48 pages), Heat Transmission Book (24 pages), Arcola Outfit Installation Book (24 pages), Lowering the High Cost of Cleaning Buildings Through Arco Wand Vacuum Cleaners catalog (12 pages), How to Run the Steam and Hot Water Boilers catalogs (12 pages), Specifications for Steam and Water Systems (8 pages), Ideal Gas Boiler Manuals (16 pages each), Drying of Lumber, Paint and Varnish catalog (48 pages), etc. May we not, therefore, request that all Heating Engineers kindly keep their names on file at our nearest local Sales Branch that they may obtain or have mailed to them latest technical catalogs.

Faithfully,

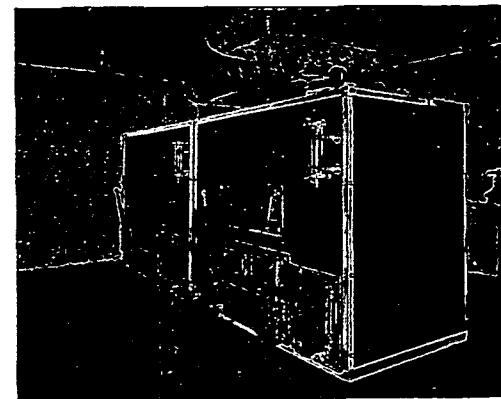
AMERICAN RADIATOR COMPANY



Illustrates (at left) the CORTO Radiator, of classic design. Its heating surface equals, or exceeds, the best; its water content is three-fourths of a pound per square foot of heating surface, or about one-half the contents of the usual form of radiator; and its condensed spacings permit of placing 30% more heating surface in a given area of floor space than with any other type of radiator.

Send for complete CORTO
Radiator Catalog.

(Pat. Sept. 4, 1917, May 10, 1921, July 19, 1921)



IDEAL Type "A" Heat Machines

IDEAL Type "A" Boilers are made in three series, ranging in Steam from 450 to 6,500 sq. ft., and in Water from 750 to 11,000 sq. ft. They specially lend themselves to installation in battery form. IDEAL Boiler ratings conform with the rating formula of the A.-S. H. & V. E.

Steam						Water					
Boiler No.	8-Hour Rating Sq. Ft.	No. of Sections	Total Length Inches	Grate Area Sq. Ft.	*Safety Valve Size Inches	Boiler No.	8-Hour Ratings Sq. Ft.	No. of Sections	Total Length	Grate Area Sq. Ft.	
3-A-5	2600	5	38	8	1-2½	3-A-50	4400	5	38	8	
3-A-6	3250	6	46	10	1-3	3-A-60	5500	6	46	10	
3-A-7	3900	7	54	12	1-3	3-A-70	6600	7	54	12	
3-A-8	4550	8	62	14	2-2½	3-A-80	7700	8	62	14	
3-A-9	5200	9	70	16	2-2½	3-A-90	8800	9	70	16	
3-A-10	5850	10	78	18	1-3, 1-2½	3-A-100	9900	10	78	18	
3-A-11	6500	11	86	20	1-3, 1-2½	3-A-110	11000	11	86	20	

Height of Water Line, 49 inches. Steam Boilers have one 8-inch Outlet, and one 5-inch Inlet. Water Boilers have one 8-inch outlet and two 8-inch inlets.

For list price, see Current Trade Discount sheet.

*Safety Valve sizes accord with A. S. M. E. boiler code.

Factors determining boiler capacities (derived from actual tests):

	5	6	7	8	9	10	11
Number of Boiler—Steam or Water	578	722	866	1012	1156	1300	1445
Fuel available, lbs.	9.0	9.0	9.0	9.0	9.0	9.0	9.0
Evaporative power, lbs.	5200	6500	7800	9110	10410	11700	13010
Total steam from one fuel charge, lbs.	256	320	400	480	560	640	720
Chimney area (sea level), sq. in.	40	45	50	55	60	65	70
Chimney height*, ft.	40	45	50	55	60	65	70

*For additional chimney flue sizes, see page 36 of "Ideal Fitter."

For Smoke Pipe and other dimensions, see pages 37 of "Ideal Fitter."

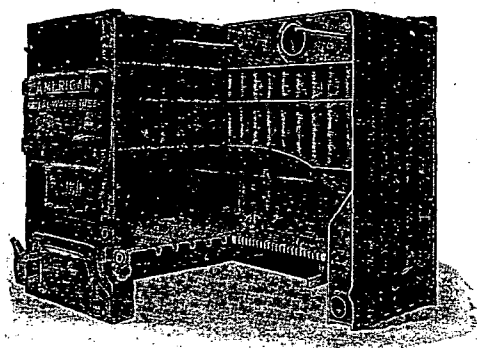
For good chimney construction and its influence on boiler selection, see pages 235 and 236 of "Ideal Fitter."

Height of boiler, 63 inches. Width of boiler, 76 1/4 inches.

For selection of proper size boiler, see pages 240-251 of "Ideal Fitter."

Ratings Developed When Available Fuel Is Burned in 8, 10 or 12 Hours

Steam Rating								Water Rating							
TIME	5 Sec.	6 Sec.	7 Sec.	8 Sec.	9 Sec.	10 Sec.	11 Sec.	5 Sec.	6 Sec.	7 Sec.	8 Sec.	9 Sec.	10 Sec.	11 Sec.	
8 Hours	2600	3250	3900	4550	5200	5850	6500	4400	5500	6600	7700	8800	9900	11000	
10 Hours	2080	2600	3120	3640	4160	4680	5200	3520	4400	5280	6160	7040	7920	8800	
12 Hours	1735	2170	2600	3035	3470	3900	4335	2935	3670	4400	5135	5870	6600	7340	



Interior View of S-79-T-13 Boiler

IDEAL 79-inch Water Tube Boilers

Without Ideal Smoke Preventing Device.

(Furnished With or Without Ideal Metallic Jacket)

IDEAL Water Tube Boilers are made in four series, ranging in Steam from 600 to 15,000 sq. ft., and in Water from 975 to 24,750 sq. ft. They specially lend themselves to installation in battery form. IDEAL Boiler ratings conform with the rating formula of the A. S. H. & V. E.

Steam

Boiler Number	Rating Sq. Ft.	Number of Sections	Total Length Inches See "L"	Grate Area Sq. Ft.	Outlets Number and Size	Inlets Number and Size	*Safety Valves Number and Size
S-79-T-7	7000	7	48	22.96	1-10	1-4	1-4
S-79-T-8	8000	8	54	26.24	1-10	1-4	1-3½, 1-2½
S-79-T-9	9000	9	60	29.52	1-10	1-4	1-3½, 1-3
S-79-T-10	10000	10	66	32.80	1-10	1-4	1-4, 1-3
S-79-T-11	11000	11	72	36.08	1-10	1-4	1-4, 1-3
S-79-T-12	12000	12	78	40.16	1-10	1-4	1-4, 1-3½
S-79-T-13	13000	13	84	44.24	1-10	1-4	2-4
S-79-T-14	14000	14	90	48.32	1-10	1-4	2-4
S-79-T-15	15000	15	96	52.40	1-10	1-4	3-3½

Height of water line, 67 inches. Height of boiler, 81¼ inches.

Water

Boiler Number	Rating Sq. Ft.	Number of Sections	Total Length Inches See "L"	Grate Area Sq. Ft.	Outlets Number and Size	Inlets Number and Size	*Safety Valves Number and Size
W-79-T-7	11550	7	48	22.96	1-10	2-10	.....
W-79-T-8	13200	8	54	26.24	1-10	2-10	.....
W-79-T-9	14850	9	60	29.52	1-10	2-10	.....
W-79-T-10	16500	10	66	32.80	1-10	2-10	.....
W-79-T-11	18150	11	72	36.08	1-10	2-10	.....
W-79-T-12	19800	12	78	40.16	1-10	2-10	.....
W-79-T-13	21450	13	84	44.24	1-10	2-10	.....
W-79-T-14	23100	14	90	48.32	1-10	2-10	.....
W-79-T-15	24750	15	96	52.40	1-10	2-10	.....

For list prices see Current Trade Discount Sheet.

*Safety Valve sizes accord with A. S. M. E. boiler code.

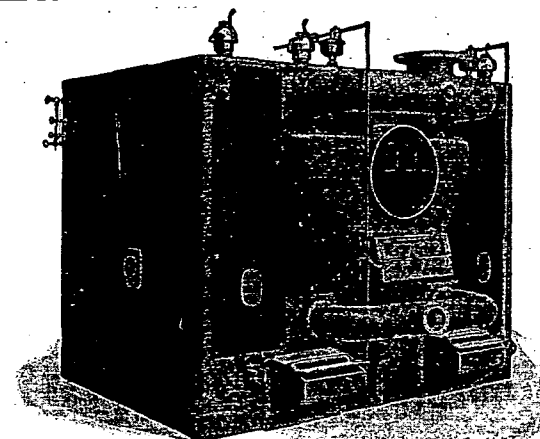
Factors Determining Boiler Capacities (derived from actual tests)

Number of Sections in Boiler	7	8	9	10	11	12	13	14	15
Fuel available, lbs.	189	216	243	270	297	324	351	378	406
Evaporative Power, lbs.	9.25	9.25	9.25	9.25	9.25	9.25	9.25	9.25	9.25
Total Steam from one fuel charge, lbs.	1750	2000	2250	2500	2750	3000	3250	3500	3750
Chimney Area (sea level), sq. in.	480	480	576	576	672	672	768	768	864
Chimney height, ft.	65	70	70	70	75	75	80	80	85

For Smoke Pipe dimensions and assemblies, see page 54 of "Ideal Fitter" catalog.

For good chimney construction, and its influence on boiler selection, see pages 235 and 236 of "Ideal Fitter" catalog.

For selection of proper size boiler, see pages 249-251 of "Ideal Fitter" catalog.



Rear View of T-79-13 Boiler

IDEAL 79-inch Water Tube Boilers

(Furnished With or Without Ideal Metallic Jacket)

With Ideal Smoke Preventing Device

IDEAL Water Tube Boilers are made in four series, ranging in Steam from 600 to 15,000 sq. ft., and in Water from 975 to 24,750 sq. ft. They specially lend themselves to installation in battery form. IDEAL Boiler ratings conform with the rating formula of the A. S. H. & V. E.

Steam

Boiler Number	Rating Sq. Ft.	Number of Sections	Total Length Inches See "L"	Grate Area Sq. Ft.	Outlets Number and Size	Inlets Number and Size	*Safety Valves Number and Size
T-79-9	9000	9	60	29.52	1-10	1-4	1-3½, 1-3
T-79-10	10000	10	66	32.80	1-10	1-4	1-4, 1-3
T-79-11	11000	11	72	36.08	1-10	1-4	1-4, 1-3
T-79-12	12000	12	78	40.16	1-10	1-4	1-4, 1-3½
T-79-13	13000	13	84	44.24	1-10	1-4	2-4
T-79-14	14000	14	90	48.32	1-10	1-4	2-4
T-79-15	15000	15	96	52.40	1-10	1-4	3-3½

Height of Water Line, 67 inches. Height of boiler, 81¼ inches.

Water

Boiler Number	Rating Sq. Ft.	Number of Sections	Total Length Inches See "L"	Grate Area Sq. Ft.	Outlets Number and Size	Inlets Number and Size	*Safety Valves Number and Size
T-79-90	14850	9	60	29.52	1-10	2-10	.....
T-79-100	16500	10	66	32.80	1-10	2-10	.....
T-79-110	18150	11	72	36.08	1-10	2-10	.....
T-79-120	19800	12	78	40.16	1-10	2-10	.....
T-79-130	21450	13	84	44.24	1-10	2-10	.....
T-79-140	23100	14	90	48.32	1-10	2-10	.....
T-79-150	24750	15	96	52.40	1-10	2-10	.....

For List Price, see Current Trade Discount Sheet.

*Safety Valve sizes accord with A. S. M. E. boiler code.

Factors determining boiler capacities (derived from actual tests)

Number of Sections in Boiler	9	10	11	12	13	14	15
Fuel available, lbs.	243	270	297	324	351	378	406
Evaporative power, lbs.	9.25	9.25	9.25	9.25	9.25	9.25	9.25
Total steam from one fuel charge, lbs.	2250	2500	2750	3000	3250	3500	3750
Chimney Area (sea level), sq. in.	576	576	672	672	768	768	864
Chimney height, ft.	70	70	75	75	80	80	85

For Smoke Pipe dimensions and assemblies, see page 54 of "Ideal Fitter" catalog.

For good chimney construction, and its influence on boiler selection, see pages 235 and 236 of "Ideal Fitter" catalog.

For selection of proper size boiler, see pages 249-251 of "Ideal Fitter" catalog.

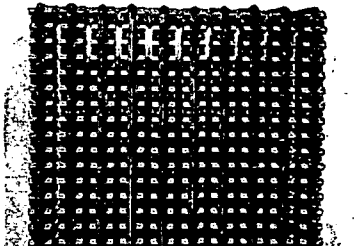
VENTO HEATERS

Regular Section—(Width 9 1/8")—Ratings and Free Areas

30-INCH SECTION HEIGHT 30 INCHES—8 SQUARE FEET				60-INCH SECTION HEIGHT 60 11-16 INCHES—16 SQUARE FEET			
Number of Sections in Stack	Square Feet of Heating Surface	5-Inch Centers of Sections		Number of Sections in Stack	Square Feet of Heating Surface	5-Inch Centers of Sections	
		Standard 44% of Face				Standard 44% of Face	
		Net Air Space in Square Feet	Width of Stack in Inches			Net Air Space in Square Feet	Width of Stack in Inches
10	80	4.60	50	10	160.0	9.21	50
11	88	5.06	55	11	176.0	10.13	55
12	96	5.52	60	12	192.0	11.05	60
13	104	5.98	65	13	208.0	11.97	65
14	112	6.44	70	14	224.0	12.89	70
15	120	6.90	75	15	240.0	13.81	75
16	128	7.36	80	16	256.0	14.73	80
17	136	7.82	85	17	272.0	15.65	85
18	144	8.28	90	18	288.0	16.57	90
19	152	8.75	95	19	304.0	17.50	95
20	160	9.21	100	20	320.0	18.42	100

40-INCH SECTION HEIGHT 41 1-64 INCHES—10.75 SQUARE FEET				72-INCH SECTION HEIGHT 72 INCHES—19 SQUARE FEET			
10	107.50	6.20	50	10	190	11.04	50
11	118.25	6.82	55	11	209	12.17	55
12	129.00	7.44	60	12	228	13.27	60
13	139.75	8.06	65	13	247	14.35	65
14	150.50	8.68	70	14	266	15.46	70
15	161.25	9.30	75	15	285	16.58	75
16	172.00	9.92	80	16	304	17.70	80
17	182.75	10.54	85	17	323	18.78	85
18	193.50	11.16	90	18	342	19.88	90
19	204.25	11.78	95	19	361	21.00	95
20	215.00	12.40	100	20	380	22.10	100

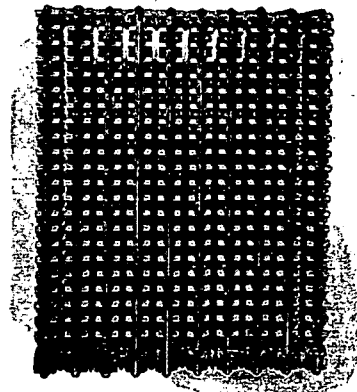
50-INCH SECTION HEIGHT 50 29-32 INCHES—13.5 SQUARE FEET			
10	135.0	7.68	50
11	148.5	8.45	55
12	162.0	9.22	60
13	175.5	9.99	65
14	189.0	10.76	70
15	202.5	11.53	75
16	216.0	12.30	80
17	229.5	13.07	85
18	243.0	13.84	90
19	256.5	14.59	95
20	270.0	15.36	100



†NOTE:—Add to the width of stack 2 1/2 inches for staggering of stacks.

ACTUAL WEIGHTS:—8.20 pounds per square foot actual, 9 pounds per square foot shipping weight.

Please ask for special and complete catalog: "Engineers Data on Vento Radiators."



The Famous Vento Heater. Now the standard for the heating of moving air

IDEAL Packless Radiator Valves

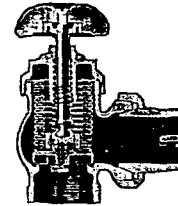
(Patents Pending)

For Low Pressure Steam or Water Heating

No packing of any kind is used. A metallic bellows allows the raising and lowering of the stem, but provides a flexible metal wall between the interior and exterior, thus making it steam, water or air tight at all times. The Ideal Packless Radiator Valve prevents damage to floors, walls, ceilings, and drapes. There is no "packing" to wear out and cause leaks around the stem. Saves the maintenance cost of repacking other types. Inexpensive insurance against damage to buildings. Turns so easily that it can be opened or closed with the finger tips. Equipped with new cool grip handle, hard rubber finish, which will not crack, break, or become loose.

Especially adapted to vacuum heating.

On special order a circulating hole will be drilled for hot water heating. Can be furnished with iron wheel handle. Lock and shield type can be furnished at extra charge.



IDEAL Airid Siphon Valve

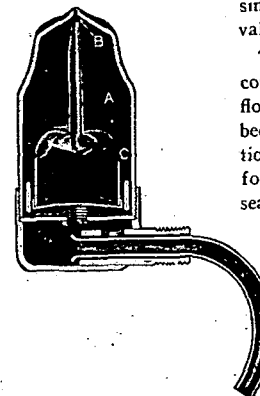
(Patent Pending)

For Venting Low Pressure Steam Radiators

The Airid Valve represents a great forward step in venting steam radiators. This invention has made possible a simplified construction which gives Engineers the best air valve ever produced at a reduced cost.

The perfect design of the Ideal Airid Siphon Valve has come through study of areas and free passages. Under flooded radiator conditions the valve vents without leak because the large separating chamber "A" allows separation of the air and water. The seat at "B" requires no guide for the pin, thus eliminating the water pocket around the seat which causes sputtering and leaking. By increasing the area "C" between the float and shell to proper proportions, it was discovered that the valve would siphon or drain perfectly without a by-pass from the stem to the air space at the top of the shell.

It is non-adjustable and made entirely of metal. Tenants cannot tamper with it. Highly nicked and polished. Made complete in our own factories under our own inspection and test. Guaranteed for five years.



Sectional View of Valve

Bayley Mfg. Co.

732 Greenbush Street

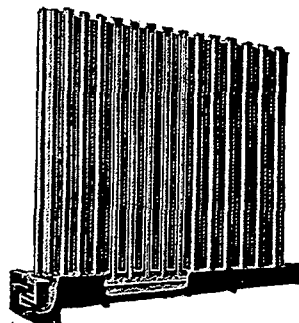
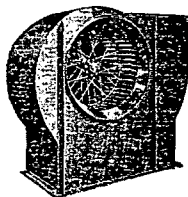
Milwaukee, Wisconsin

Heating, Ventilating, Air-Washing, Exhaust and Drying Equipment

Separate bulletins are issued on Air Washers, B. T. U. Heaters, Dryers, Chinook Heaters, Plexiform Fans, Exhaust Fans, Disc Fans, Air Washers. These will be furnished on request. The Company also furnishes engineering service in connection with the application of any of the products manufactured.

Plexiform Fans

A well-balanced fan for ventilating public, office and industrial buildings, mines, tunnels, etc., and for heating, drying and air washing systems. Space and power economy are some of the advantages it offers.

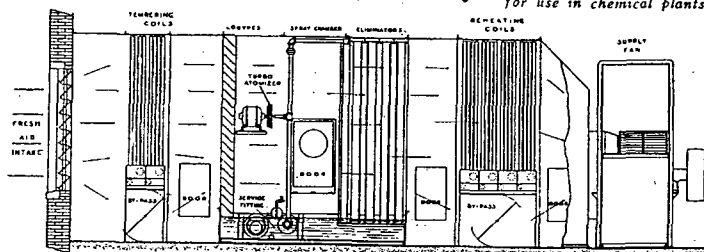
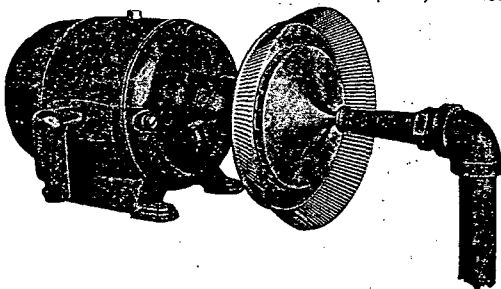


Chinook Heaters

The Bayley Chinook Heater is a tube-within-a-tube radiator without return bends, elbows or nipples. Circulation is established from the steam chamber through the inner tube, and back through the outer tube to the return chamber. Used in connection with the Plexiform fan, also for direct and indirect radiation, and for cooling water.

Bayley Turbo-Air Washer

The superiority of this Washer is in the atomizer, which atomizes the liquid by means of a rapidly rotating cone with pins at its periphery. Clogging is eliminated, as the water is delivered to the cone through a nozzle with a large orifice and at low pressure. The non-clogging feature assures a steady, uniform spray, which insures intimate contact between the air and the spray. No screen in pump intake. Atomizer fits any air washer. Washers made in various sizes for washing air or gases and for use in chemical plants.



Ilg Electric Ventilating Company

GENERAL OFFICES AND WORKS

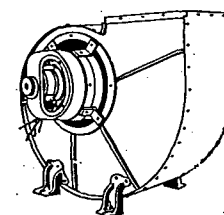
2880 N. Crawford Ave.,

Chicago, Ill.

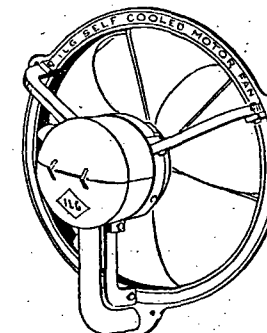
DISTRICT SALES OFFICES

NEW YORK, 13 Park Row CLEVELAND, 1314 Schofield Bldg. DETROIT, 203 Owen Bldg.
PHILADELPHIA, 327 Commercial Trust Bldg. PITTSBURGH, 1024 Bessemer Bldg.

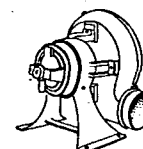
Branches in all principal cities



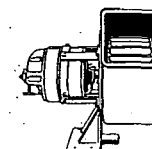
Ilg Direct-Connected Blowers
Sizes 25" to 90"
For any current and voltage



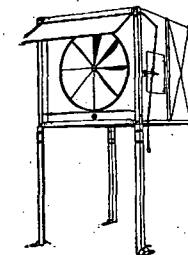
Ilg Self-Cooled Motor Propeller Fans
Sizes 12" to 72"
For any current and voltage



Ilg Type P Blowers
Sizes 10", 15", 20"
For Pressures from 1/2" to 2 1/2"



Ilg Type V Blowers
Sizes 10", 15", 20"
For small volumes at low pressures



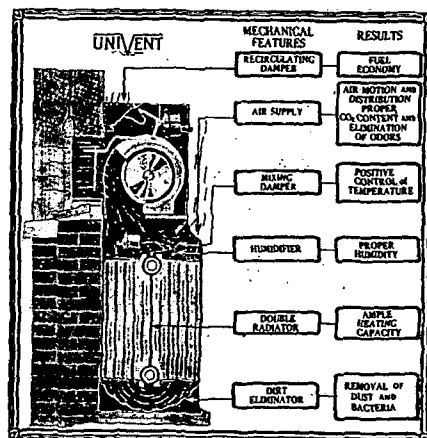
Ilgair Unit Heaters
The Unit Heater with the Ilg Self-Cooled Propeller Fan

The Herman Nelson Corporation

Main Office
Moline, Illinois

Sales Representatives in all Principal Cities

The Univent Unit Heating & Ventilating Systems.



To the Engineer:

Owing to the fact that each room is treated separately, Univents offer an extremely simple and satisfactory solution of the heating and ventilating problem.

Having determined upon a Univent system, the Engineer can prepare his preliminary sketches without further thought to heating and ventilating, knowing that he will not have to tear down his building to install it, or be handicapped in meeting his estimated cost by the addition of space or

expensive construction. The Engineer can present his scheme of heating and ventilating to his prospective client in a comprehensive manner without the necessity of preparing elaborate and costly plans.

The Univent manufacturers are prepared to furnish reliable estimates which can be predetermined from preliminary sketches.

Moreover, the fact that the building construction need not be materially changed, assists the architect and engineer to make much closer estimates of cost for the entire building.

A copy of the Architects' and Engineers' Univent catalog containing complete engineering data will be sent upon request. It will enable the Engineer to prepare complete heating and ventilating plans and specifications with little effort, and the Univent manufacturers will be glad to co-operate to the fullest extent.

Finally, the Univent system simplifies the work of installation, eliminates the complex problem heretofore encountered with other systems in balancing the air distribution, and assures a satisfactory ventilating system.

The Herman Nelson Corporation

Heating and Ventilating

A few of the buildings in which the Univent system has been installed during 1920-21. A complete list of Univent Installations furnished upon request.

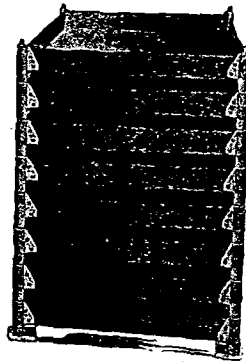
Town	Kind of Building	Town	Kind of Building
STATE OF CALIFORNIA		STATE OF MINNESOTA	
Martinez	School	Hackensack	School
STATE OF COLORADO		Minneapolis	School
Denver	School	Sleepy Eye	School
STATE OF CONNECTICUT		St. Paul	School
Seymour	School	STATE OF MISSOURI	
New Haven	School	Kansas City	School
STATE OF IDAHO		St. Joseph	School
Rexburg	School	STATE OF NEW JERSEY	
STATE OF ILLINOIS		Hawthorne	School
East Moline	School	Paterson	School
Moline	{ School (2) Banks Office	Union Hill	School
Rock Island	(3) Schools	STATE OF NEW YORK	
Sheffield	School	Jamestown	(5) Schools
STATE OF IOWA		Sloan	(2) Schools
Ainsworth	School	Stella	School
Clinton	(2) Schools	Tonawanda	School
Creston	School	Utica	(2) Banks
Coburg	School	Yonkers	School
Des Moines	School	STATE OF OHIO	
Hedrick	School	Columbus	State Senate Chamber
Glidden	School	Cuyahoga Falls	School
Patterson	School	Lima	Club
Redfield	School	Maple Heights	School
Stennett	School	Youngstown	School
STATE OF KANSAS		STATE OF OKLAHOMA	
Topeka	(2) Schools	Ringling	School
STATE OF MARYLAND		STATE OF PENNSYLVANIA	
Baltimore	School	Avoca	School
STATE OF MICHIGAN		Glen Lyon	School
Detroit	Office Bldg.	Nanticoke	(2) Schools
Grand Rapids	(5) Schools	New Castle	School
		Pittston	School
		Vandling	School
		STATE OF WASHINGTON	
		Mt. Vernon	School

York Heating and Ventilating Corp.

250 South Broad Street

Philadelphia

Metal Drying Trays, Blast Gates, Damper Quadrants, Dust Collectors



York Metal Drying Trays

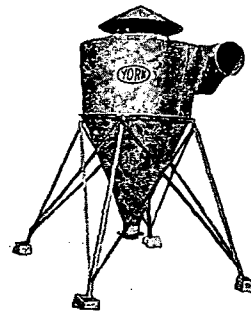
York Metal Drying Trays, with patented nesting corners, may be stacked on a batten as high as desired without liability of toppling. They can then be moved as a unit without rehandling each individual tray.

The patented nesting corners enable York trays to be stacked evenly, one above the other; provide uniform space between trays, thus insuring perfect air circulation, without use of shelves, special trucks, etc. The nesting corners add to strength and rigidity of the tray and are hollowed out permitting easy and thorough cleaning.

York trays can be furnished with solid or perforated bottoms; made of steel, copper, brass, aluminum or any special metal.

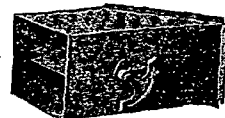
Catalogue furnished on request.

Complete Blower Systems for Ventilating or Exhausting, built and installed



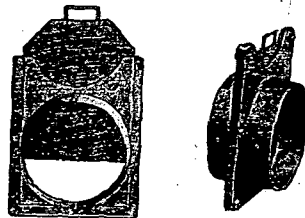
York Cyclone Dust Collector

Made in all sizes with or without supporting frame.



York Damper Quadrant

York Quadrant will securely hold large dampers firmly in any desired position.



York Blast Gates

Note a special feature of the York Blast Gate,—the thumb adjusting set screw for holding gate in any desired position.

The Bahnson Company

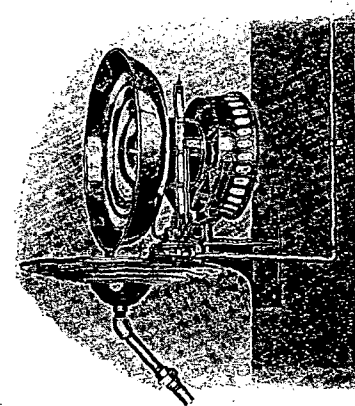
Winston-Salem, N. C.

New York Sales Office, 437 Fifth Avenue

Bahnson Humidifiers

The Bahnson Company specializes on Bahnson Humidifiers, which are supplied in units of only one size. Varying conditions of use are met by mechanically interchangeable motors for different current supply, and by supporting hangers for mounting the machines on round columns, square columns, walls, or for support from ceiling or floor.

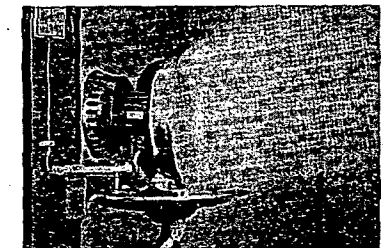
the disc depends on the peripheral speed of the disc, and is practically independent of the amount of water fed to the machine, Bahnson Humidifiers possess the unique feature of an adjustable water supply. The percentage of the feed water thrown out in particles is the same regardless of the actual amount of such feed water, so that without sacrificing



Bahnson Humidifier mounted on corner of square column

Each Bahnson Humidifier is a complete, self-contained humidifying unit, operated by its individual motor, with its own accurate, dependable humidity control. On one end of the motor shaft is a conical disc sixteen inches in diameter and on the other end a propeller type fan. Water, preferably at pressures below twenty-five pounds per square inch, is fed through the controlling mechanism to the center of the revolving disc and is thrown by centrifugal force from the rim of the disc against a series of stationary copper teeth surrounding but not touching the disc. This impact breaks up the water into very fine particles which, in the form of mist or fog, are blown out into the room by the fan. The water is actually evaporated in the room itself.

Since the speed of the water striking



Reproduction unretouched photograph of Bahnson Humidifier in operation

efficiency the evaporation may be adjusted at any point from a few drops per minute up to the maximum capacity of the humidifier.

The horizontal movement of air produced by the fan renders it easy to arrange an equipment of Bahnson Humidifiers so as to get a complete circulation all around the room, and the combination of this circulation with the automatic control on each unit insures not only constant humidity, but also remarkably uniform distribution.

The Bahnson Company's engineers will gladly submit proposals based on architect's drawings or sketch plans. The number of units required in any room depends upon the length, breadth and ceiling height, the process carried on in the room, and the relative humidity required at a specified temperature.

Celite Products Company

53 W. Jackson Blvd.

Chicago

NEW YORK, 11 Broadway
BOSTON, 79 Milk St.
BUFFALO, Mutual Life Bldg.
CINCINNATI, Union Central Bldg.
CLEVELAND, Bulkeley Bldg.
DENVER, Symes Bldg.
DETROIT, Book Bldg.

LOS ANGELES, Van Nuys Bldg.
MINNEAPOLIS, 251 Sixth Ave., So.
NEW ORLEANS, Whitney Central Bank Bldg.
PHILADELPHIA, Bulletin Bldg.
SAN FRANCISCO, Monadnock Bldg.
ST. LOUIS, Railway Exchange Bldg.

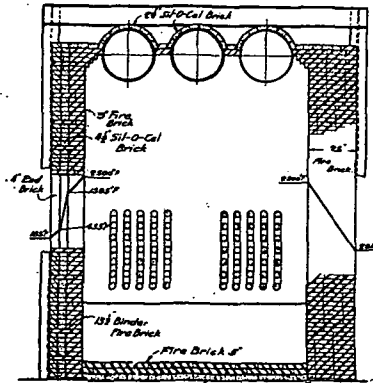
SIL-O-CEL Insulation prevents heat loss due to the radiation of heat through the walls and settings of all types of heated equipment. It is used as an insulating backing for the refractory lining and is laid up between fire brick and outer walls.

Tests of the insulating value of SIL-O-CEL prove it to be one-tenth as conductive as fire brick inch for inch. It is unaffected by temperatures which completely destroy other forms of insulation and it will stand a direct heat of 1600 degrees F. without shrinkage. SIL-O-CEL does not melt until 2,930 degrees F. (1610 degrees C); it is sufficiently compressible and elastic to take up the strains due to expansion and contraction; it will not fuse, settle or shrink when placed against the highly heated refractory lining.

Boiler Insulation

The efficiency of a boiler depends on the differential temperature between the water in the boiler and flue gases and the amount of radiant energy given off by the fuel bed and luminous flames. The amount of heat radiated from a boiler setting is usually given by authorities as small and is, therefore, many times disregarded. The actual loss, however, is high, since the loss of heat lowers the differential temperature and hence the boiler efficiency because heat cannot be absorbed effectively from boiler flue gases which are colder than from 500 degrees to 600 degrees F. Radiant energy is absorbed most readily by the boiler since it requires no material agency for

its propagation and does not depend on convection; but this radiant energy is absorbed by the brick work as well as the boiler and is lost by radiation from the settings, unless measures are taken to prevent it.



Heat Loss Through Uninsulated Wall 872 B.t.u. per sq. ft. per hr.
Heat Loss Through Insulated Wall 338 B.t.u. per sq. ft. per hr.
Heat Saving 534 B.t.u. or 53.4%

Tests of Insulation Savings

Tests of insulated and uninsulated equipment prove the saving secured through SIL-O-CEL. With an internal temperature of 2500 degrees F. and a room temperature of 100 degrees F. the exterior of an uninsulated wall showed a heat loss of 872 B.t.u., whereas the heat loss of the exterior of the insulated wall was only 338 B.t.u.

This difference of 534 B.t.u. corresponds to a saving through SIL-O-CEL insulation of 43 pounds of coal, 4.3 gallons of oil, or 867 cubic feet of natural gas for each thousand square feet of radiating surface each hour.

Engineering Service

An engineering department is maintained for the purpose of providing additional data on any specific heat insulating problem which may confront you, and the services of our technical staff are available at all times without cost or obligation. Address the nearest office given above.



Robert A. Keasbey Company

Main Office and Warehouse:

Bank and West Streets

New York City

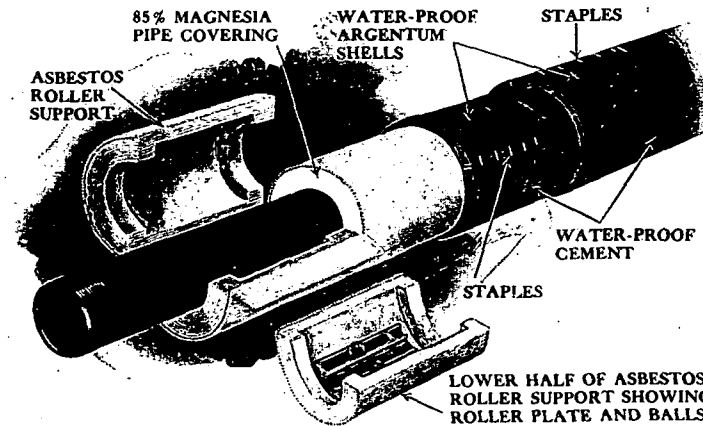
Branches:

100 Catherine St., Syracuse, N. Y.

300 Asylum St., Hartford, Conn.

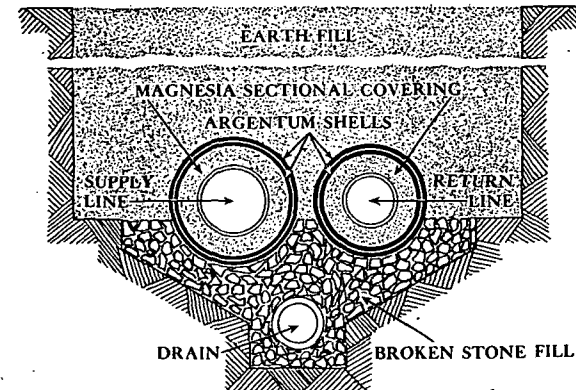
Pipe and Boiler Coverings, Heat and Cold Insulation
Contracts Executed

Argentum Insulation For Underground Piping



This System provides a simple and logical method of insulating underground steam or hot water pipes in connection with Central Heating Plants, large Institutions, Schools, Universities, Hospitals, Garages, etc.

This type of insulation in a modified form is excellent for piping running in unexcavated portions or buried in ground subject to dampness under buildings. Specifications, data and prices furnished upon request.



Crane Co. Chicago

Largest Manufacturers and Distributors of Pipe, Valves and Fittings
in the World.

FLOW OF STEAM IN POUNDS PER MINUTE THROUGH STANDARD AND EXTRA STRONG PIPES AND PRESSURE DROP OF
STEAM IN POUNDS THROUGH 100 FEET STANDARD AND EXTRA STRONG PIPES
VELOCITY, 3000 FT. PER MINUTE
TABLES FURNISHED BY CRANE CO.

GAUGE PRESSURE IN POUNDS PER SQUARE INCH

Size	STANDARD PIPE										EXTRA STRONG PIPE		
	1	3	5	10	15	25	35	50	75	100	125	150	200
1/4 Flow	.255	.286	.315	.388	.461	.604	.745	.953	1.296	1.632	1.965	2.304	2.962
Drop	1.537	1.746	1.903	2.352	2.790	3.656	4.515	5.775	7.845	9.88	11.87	13.96	17.92
1/4 Flow	.448	.501	.553	.681	.808	1.058	1.305	1.669	2.221	2.860	3.445	4.038	5.190
Drop	9.06	1.014	1.118	1.380	1.636	2.140	2.640	3.377	4.600	5.780	6.962	8.180	9.375
1 Flow	.726	.812	.896	1.105	1.310	1.715	2.115	2.705	3.681	4.636	5.588	6.548	7.490
Drop	.597	.668	.736	.910	1.079	1.410	1.740	2.222	3.028	3.803	4.595	5.400	6.172
1 1/4 Flow	1.256	1.406	1.552	1.912	2.270	2.968	3.662	4.683	6.372	8.030	9.670	11.32	12.97
Drop	.369	.414	.457	.564	.668	.875	1.076	1.379	1.873	2.363	2.842	3.333	3.825
1 1/2 Flow	1.711	1.914	2.111	2.604	3.086	4.042	4.986	6.380	8.670	10.93	13.17	15.42	17.65
Drop	.284	.318	.351	.434	.512	.671	.828	1.061	1.440	1.817	2.187	2.567	2.938
2 Flow	2.818	3.152	3.480	4.290	5.085	6.660	8.215	10.51	14.29	18.01	21.68	25.42	29.08
Drop	.187	.211	.232	.286	.338	.444	.548	.697	.950	1.198	1.442	1.694	1.938
2 1/2 Flow	4.012	4.501	4.968	6.122	7.260	9.515	11.73	13.00	20.41	23.70	30.95	36.27	41.55
Drop	.140	.158	.174	.215	.254	.334	.411	.525	.714	.869	1.082	1.272	1.437
3 Flow	6.211	6.945	7.665	9.455	11.21	14.68	18.10	23.14	31.48	39.67	47.80	56.00	64.15
Drop	.099	.112	.123	.153	.181	.237	.293	.374	.508	.641	.771	.905	1.040
4 Flow	10.69	11.96	13.20	16.27	19.30	25.27	31.17	39.87	54.25	68.30	82.30	96.45	110.3
Drop	.066	.074	.082	.101	.120	.157	.194	.248	.338	.424	.512	.600	.687
5 Flow	16.83	18.82	20.75	25.58	30.33	39.73	49.00	62.70	85.35	107.3	129.5	151.6	173.5
Drop	.048	.054	.059	.073	.087	.114	.140	.179	.244	.306	.370	.433	.497
6 Flow	24.27	27.16	29.96	36.94	43.80	57.35	70.75	90.50	123.2	155.1	186.8	218.0	250.5
Drop	.037	.042	.046	.057	.067	.088	.109	.139	.189	.238	.286	.333	.384
8 Flow	42.95	48.08	53.03	65.38	77.50	101.5	125.2	161.2	217.8	274.4	330.7	387.3	443.3
Drop	.025	.028	.031	.039	.046	.060	.074	.094	.129	.162	.195	.228	.262
10 Flow	67.80	75.85	83.70	103.2	122.4	160.2	197.7	255.8	343.8	433.0	522.0	611.8	699.0
Drop	.019	.021	.023	.029	.034	.045	.055	.071	.096	.121	.146	.171	.195
12 Flow	96.50	107.9	119.1	146.8	174.2	228.0	281.2	359.5	489.2	616.2	742.0	870.0	995.0
Drop	.015	.017	.019	.023	.028	.036	.044	.057	.077	.097	.117	.137	.157

FLOW OF STEAM IN POUNDS PER MINUTE THROUGH STANDARD AND EXTRA STRONG PIPES AND PRESSURE DROP OF
STEAM IN POUNDS THROUGH 100 FEET
STANDARD AND EXTRA STRONG PIPES
VELOCITY, 4000 FT. PER MINUTE

GAUGE PRESSURE IN POUNDS PER SQUARE INCH

Size	STANDARD PIPE										EXTRA STRONG PIPE		
	1	3	5	10	15	25	35	50	75	100	125	150	200
1/4 Flow	.340	.381	.420	.518	.614	.805	.993	1.270	1.727	2.175	2.620	3.072	3.515
Drop	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
1/4 Flow	.597	.668	.737	.908	1.077	1.411	1.740	2.225	3.029	3.814	4.593	5.382	6.160
Drop	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
1 Flow	.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
Drop	1.061	1.190	1.310	1.616	1.913	2.492	3.090	3.956	5.385	6.775	8.165	9.585	10.99
1 1/4 Flow	1.625	1.873	2.068	2.548	3.023	3.958	4.882	6.241	8.490	10.70	12.88	15.11	17.28
Drop	.657	.734	.811	1.000	1.185	1.535	1.915	2.448	3.330	4.190	5.045	5.938	6.796
1 1/2 Flow	2.281	2.551	2.816	3.471	4.113	5.388	6.650	8.500	11.57	14.57	17.56	20.56	23.53
Drop	.503	.566	.624	.770	.910	1.194	1.472	1.883	2.564	3.222	3.869	4.555	5.222
2 Flow	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
Drop	.334	.376	.412	.509	.602	.788	.976	1.243	1.690	2.160	2.562	3.110	3.448
2 1/2 Flow	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
Drop	.250	.280	.309	.382	.452	.592	.731	.933	1.270	1.598	1.926	2.260	2.585
3 Flow	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
Drop	.177	.199	.220	.272	.322	.421	.520	.664	.905	1.138	1.370	1.610	1.840
4 Flow	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
Drop	.118	.133	.146	.181	.214	.279	.345	.441	.600	.755	.911	1.068	1.235
5 Flow	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
Drop	.085	.096	.106	.130	.154	.202	.249	.318	.433	.546	.656	.768	.883
6 Flow	32.36	36.22	39.95	49.23	58.38	76.48	94.30	120.7	164.2	206.7	249.0	291.8	334.0
Drop	.066	.074	.082	.101	.119	.156	.193	.247	.336	.422	.508	.597	.683
8 Flow	57.30	64.10	70.72	87.15	103.4	135.4	166.9	213.6	291.0	365.9	440.8	516.5	591.0
Drop	.045	.051	.056	.069	.082	.107	.131	.167	.229	.287	.346	.406	.465
10 Flow	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
Drop	.034	.038	.042	.052	.061	.080	.098	.126	.171	.214	.258	.304	.348
12 Flow	128.6	143.8	158.8	195.7	232.0	303.9	374.6	479.3	652.0	821.5	989.0	1159	1327
Drop	.027	.031	.034	.042	.049	.064	.079	.101	.137	.172	.208	.244	.280

FLOW OF STEAM IN POUNDS PER MINUTE THROUGH STANDARD AND EXTRA STRONG PIPES AND PRESSURE DROP OF
STEAM IN POUNDS THROUGH 100 FEET
STANDARD AND EXTRA STRONG PIPES
VELOCITY, 5000 FT. PER MINUTE

GAUGE PRESSURE IN POUNDS PER SQUARE INCH																			
STANDARD PIPE															EXTRA STRONG PIPE				
Sizes	1	3	5	10	15	25	35	50	75	100	125	150	175	200	150	175	200	Sizes	
1/4 Flow	426	476	526	648	768	1006	1241	1587	2159	2718	3275	3838	4392	4935	2954	3380	3798	1/2	
Drop	4290	4840	5303	6545	7745	1126	1253	1600	2177	2738	3300	3875	4438	4972	4925	5640	6330	3/4	
3/4 Flow	746	835	923	1136	1347	1764	2176	2783	3783	4765	5741	6730	7700	8651	5470	6255	7030	1	
Drop	2520	2822	3135	3838	4545	5950	7340	9380	1275	1638	1935	2275	2603	2940	2808	3203	3614	1 1/4	
1 Flow	1210	1334	1494	1842	2182	2859	3527	4510	6138	7728	9310	1091	1248	1403	9080	1038	1167	1 1/2	
Drop	1660	1858	2048	2530	2993	3920	4840	6182	8420	1060	1293	1498	1716	1927	1764	2020	2266	1 3/4	
1 1/4 Flow	2093	2342	2586	3185	3778	4943	6100	7808	1061	1337	1611	1888	2161	2428	1620	1854	2082	2	
Drop	1026	1148	1268	1564	1850	2428	2990	3833	5190	6545	7890	927	1062	1190	1062	1215	1354	2 1/4	
1 1/2 Flow	2852	3190	3520	4340	5144	6738	8315	1063	1447	1821	2195	2572	2942	3304	2231	2553	2868	2 1/2	
Drop	990	885	976	1204	1428	1865	2304	2942	4013	5045	6080	7130	8160	9160	8040	9210	1033	3	
2 Flow	4698	5255	5800	7148	848	1110	1369	1752	2383	3000	3614	4237	4844	5442	3730	4270	4793	3 1/2	
Drop	522	587	644	795	945	1232	1520	1938	2645	3330	4010	4705	5385	6035	5230	5998	6720	2 1/2	
2 1/4 Flow	6708	7500	8280	1021	1210	1586	1955	2500	3400	4283	5160	6045	6918	7775	5350	6122	6872	2 1/2	
Drop	391	438	483	597	706	927	1142	1458	1983	2497	3010	3533	4040	4540	3890	4460	4985	5	
3 Flow	1036	1158	1278	1575	1867	2447	3018	3860	5248	6610	7965	9330	1068	1200	8340	9545	1072	5	
Drop	277	312	345	425	503	658	815	1040	1430	1778	2143	2515	2886	3260	2743	3180	3522	6	
4 Flow	1783	1994	2202	2713	3215	4213	5195	6645	9040	1138	1372	1606	1840	2067	1452	1662	1865	6	
Drop	185	207	228	284	333	437	539	691	940	1180	1423	1668	1910	2140	1820	2062	2275	7	
5 Flow	28	31.33	34.58	42.60	50.52	66.21	81.65	104.3	142.0	178.8	215.5	252.5	289.0	324.6	229.6	263.0	295.4	7	
Drop	132	149	165	210	240	315	389	497	676	882	1025	1203	1380	1545	1287	1476	1657	8	
6 Flow	40.42	45.23	49.93	61.55	73.00	95.70	117.9	150.7	205.2	258.3	311.2	364.7	417.5	468.7	328.9	376.6	423.0	8	
Drop	103	116	128	158	187	245	302	384	525	660	794	931	1068	1196	1000	1145	1283	9	
8 Flow	71.61	80.20	88.40	108.9	129.2	169.3	208.7	267.0	363.2	457.5	551.3	645.8	739.0	831.0	576.8	659.8	741.8	9	
Drop	071	079	087	107	127	167	206	262	357	450	541	635	727	817	686	784	880	10	
10 Flow	113.1	126.4	139.5	171.8	203.8	267.0	329.4	421.0	573.0	721.8	869.0	1019	1166	1310	943.0	1078	1212	10	
Drop	053	059	065	080	095	124	153	196	267	334	403	475	542	610	498	570	637	12	
12 Flow	160.7	179.8	198.5	244.6	290.0	380.0	468.5	599.0	815.5	1027	1237	1449	1658	1863	1368	1567	1762	12	
Drop	042	048	053	065	077	100	123	158	215	269	325	381	437	490	393	451	508	12	

Buffalo Steam Pump Co.

Buffalo, N. Y.

BRANCH OFFICES:

NEW YORK, N. Y., 39-41 Cortlandt St.
PHILADELPHIA, PA., 1303 Land Title Bldg.
BOSTON, MASS., 88 Broad St.
CLEVELAND, OHIO, 368 Kirby Bldg.
PITTSBURG, PA., 917 Union Arcade
DETROIT, MICH., Coon DeVisser Co.
CHICAGO, ILL., 562 W. Washington Blvd.
WASHINGTON, D. C., Washington Loan & Trust Bldg.

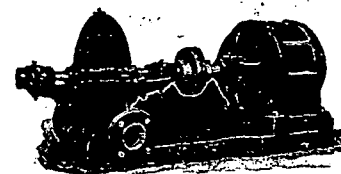
ST. LOUIS, MO., 515 Chemical Bldg.
CINCINNATI, O., 607 Mercantile Library Bldg.
MINNEAPOLIS, MINN., 120 South Ninth St.
DENVER, COLO., 1718 California St.
LOS ANGELES, CALIF., 636 H. W. Hellman Bldg.

CHARLOTTE, N. C., J. W. Fraser & Co.
NEW ORLEANS, LA., Woodward Wight & Co.
KANSAS CITY, MO., J. F. Pritchard & Co.

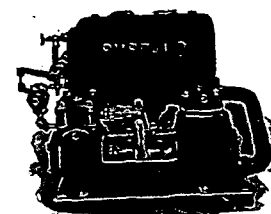
Canadian Blower & Forge Co., Kitchener, Ont.

PRODUCTS:

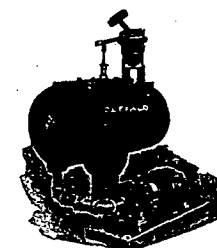
Centrifugal Pumps for all purposes—Single and Double Suction, Single and Multistage, Horizontal and Vertical.
Steam Pumps—Duplex and Simplex, Inside Packed and Outside Packed. Vacuum Pumps and Condensers.



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.

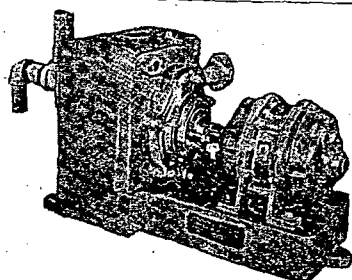
The Nash Engineering Company

South Norwalk, Conn. U. S. A.

SALES OFFICES

INDIANAPOLIS—Hume-Mansur Building
KANSAS CITY—Mutual Building
LOS ANGELES—218 East Third Street
MINNEAPOLIS—501 S. Sixth Street
MONTREAL—84 Inspector Street
NEW ORLEANS—521 Baronne Street
PHILADELPHIA—350 Madison Ave.
PORTLAND—224 Pine Street
BOSTON—185 Devonshire Street
BUFFALO—1044 Ellicott Square
CHICAGO—122 Monadnock Block

CLEVELAND—326 Frankfort Ave., N. W.
DALLAS—Dallas Bank Building
DENVER—Boston Building
DETROIT—Kear Building
HOUSTON—Southern Pacific Building
PITTSBURGH—Oliver Building
SALT LAKE CITY—Dooly Building
SAN FRANCISCO—Sharon Building
SEATTLE—220 Railway Exchange
ST. LOUIS—Chemical Building
TORONTO—136 Huron Street
WASHINGTON—710 14th Street, N. W.



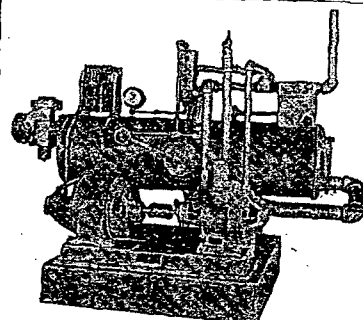
Jennings HYTOR Vacuum Pumps for Return Line Heating Systems, remove air and water and automatically return water to boiler or hot well. Pump consists of two independent units—a Hytor turbine air pump and a Jennings centrifugal water pump—combined in one casing. Air and water are pumped separately, thus saving in horsepower is over 50% and cost of current is reduced proportionately.

Require one-third the space necessary for other apparatus. Interior parts bronze. Moving parts revolve without contact, supported on annular ball bearings mounted outside casing.

Furnished direct connected to standard electric motors or for belt drive, also with steam turbine designed to operate at steam pressure of 75 lbs., but this can be varied. Turbine units are designed to discharge condensate against boiler pressure not exceeding 20 lbs.

Standard Sizes and Capacities, Jennings Hytor Vacuum Pumps

Size	Square Feet radiation surface	Air Capacity cubic feet per min.	Water Capacity direct equivalent 10 lbs. pres.		Actual Horse Power	R. P. M.	Horse Power of Motor
			180° F.	212° F.			
M	5,000	3	8	1700	.6	1700	1/4
A	8,000	6	11	1800	.9	1800	1
B	16,000	11	22	1.4	1.800	1800	1 1/2
C	26,000	19	35	2.0	1800	1800	2
D	40,000	25	42	2.8	1200	1200	3
E	65,000	42	90	3.9	1200	1200	5
F	100,000	75	140	9.	1200	900	10
G	150,000	90	200	10.	900	720	10
H	250,000	180	400	19.	720		20



This new addition to our well known line has ample capacity for 4,000 square feet of equivalent direct radiation.

Because of simplified design, in connection with quantity production, this unit is being sold at a price never before possible in a pump of this capacity.

Equipped with solid bronze air rotor, rotor housing, water impeller and shaft.

Only necessary to make three connections: 1. Return main, 2. Water discharge, 3. Air discharge.

Air capacity 3 cu. ft. per min., measured at 10" mercury vacuum. Pump at same time handles 6 gals. water per min. from vacuum of 10" mercury against 10 lbs. gauge pressure at pump. Under these conditions pump requires 3/4 h. p. motor.

Write for Bulletin and Prices.

The Trane Company

La Crosse, Wis.

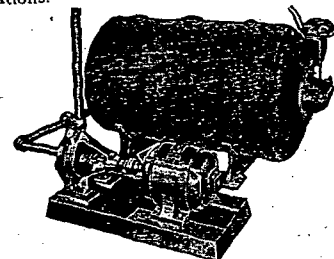
Chicago, New York, Boston, Cleveland, Buffalo, Salt Lake City, Philadelphia, Detroit, Washington, D. C., Portland, Ore., Seattle

The Trane System of Vapor Heating, Patented Heating Specialties
Trane Automatic Electric Pumps, For All Purposes

Trane Condensation Pumps

PUMP—All pumps are high grade centrifugal units of guaranteed capacity as stated for pump number shown.

MOTOR—All motors used are of well-known standard makes, guaranteed by the manufacturers. Repulsion induction motors supplied for single phase installations.



600-3000 Series Trane Condensation Pump

COUPLING—Flexible leather coupling is used between motor and pump.

AUTOMATIC FLOAT SWITCH—All units are equipped with the Trane Automatic Float Switch, double pole contact type.

RECEIVING TANK—All units, except the 400 Series, are equipped with heavy cylindrical steel tanks; 30 gallons capacity for 600 to 1000 Series, inclusive, and 40 gallons capacity for 1500 to 3000 Series, inclusive. 400 Series units are equipped with 10-gallon, elliptical, cast iron tanks.

BASE AND TANK STANDS are made of best grade grey cast iron, substantially ribbed and reinforced.

CAPACITIES

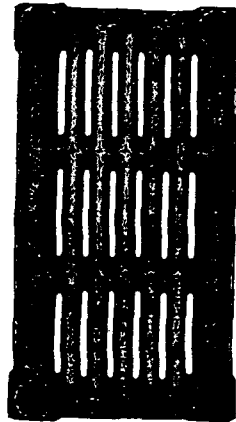
Pump Number	Minimum Gallon per Minute	Maximum Boiler Pressure	Motor H. P.	Suction and Disch.	Shipping Weight
400 Series—4,000 Sq. Ft. of Radiation					
405	6-8	5	1/2	1 1/2"	315
410	6-8	10	1/2	1 1/2"	315
415	6-8	15	1/2	1 1/2"	315
420	6-8	20	1/2	1 1/2"	315
430	6-8	30	1/2	1 1/2"	315
440	6-8	40	1/2	1 1/2"	315
450	6-8	50	1/2	1 1/2"	315
460	6-8	60	1/2	1 1/2"	315
600 Series—6,000 Sq. Ft. of Radiation					
610	9-12	10	1 1/2	1 1/2"	450
615	9-12	15	1 1/2	1 1/2"	450
620	9-12	20	1 1/2	1 1/2"	450
630	9-12	30	1 1/2	1 1/2"	500
640	9-12	40	1 1/2	1 1/2"	500
650	9-12	50	1 1/2	1 1/2"	500
660	9-12	60	1 1/2	1 1/2"	500
800 Series—8,000 Sq. Ft. of Radiation					
810	12-16	10	2	1 1/2"	500
815	12-16	15	2	1 1/2"	500
820	12-16	20	2	1 1/2"	515
830	12-16	30	2 1/2	1 1/2"	550
840	12-16	40	2 1/2	1 1/2"	550
850	12-16	50	2 1/2	1 1/2"	550
860	12-16	60	2 1/2	1 1/2"	550
1000 Series—10,000 Sq. Ft. of Radiation					
1010	15-20	10	3	1 1/2"	515
1015	15-20	15	3	1 1/2"	515
1020	15-20	20	3	1 1/2"	515
1030	15-20	30	3 1/2	1 1/2"	550
1040	15-20	40	3 1/2	1 1/2"	550
1050	15-20	50	3 1/2	1 1/2"	575
1060	15-20	60	3 1/2	1 1/2"	575
1500 Series—15,000 Sq. Ft. of Radiation					
1510	24-30	10	5	2"	515
1515	24-30	15	5	2"	515
1520	24-30	20	5 1/2	2"	515
1530	24-30	30	5 1/2	2"	575
1540	24-30	40	5 1/2	2"	575
1550	24-30	50	5 1/2	2"	600
1560	24-30	60	5 1/2	2"	600
2000 Series—20,000 Sq. Ft. of Radiation					
2010	30-40	10	7 1/2	2 1/2"	575
2015	30-40	15	7 1/2	2 1/2"	575
2020	30-40	20	7 1/2	2 1/2"	575
2030	30-40	30	7 1/2	2 1/2"	600
2040	30-40	40	7 1/2	2 1/2"	625
2050	30-40	50	7 1/2	2 1/2"	625
2060	30-40	60	7 1/2	2 1/2"	625
2500 Series—25,000 Sq. Ft. of Radiation					
2510	40-50	10	10	2 1/2"	550
2515	40-50	15	10	2 1/2"	575
2520	40-50	20	10	2 1/2"	575
2530	40-50	30	10	2 1/2"	600
2540	40-50	40	10	2 1/2"	625
2550	40-50	50	10	2 1/2"	625
2560	40-50	60	10	2 1/2"	625
3000 Series—30,000 Sq. Ft. of Radiation					
3010	50-60	10	12 1/2	2 1/2"	575
3015	50-60	15	12 1/2	2 1/2"	600
3020	50-60	20	12 1/2	2 1/2"	600
3030	50-60	30	12 1/2	2 1/2"	625
3040	50-60	40	12 1/2	2 1/2"	625
3050	50-60	50	12 1/2	2 1/2"	675
3060	50-60	60	12 1/2	2 1/2"	675

Fowler & Wolfe Mfg. Co.

Bulletin Building
Philadelphia, Pa.
Fowler & Wolfe Wall Radiators

Made in 6 sizes, as follows:

- 10 sq. ft. Section; 24"x13¼"x3½"; in Plain pattern only; vertical and horizontal forms.
- 9 sq. ft. Section; 24"x13"x3¼"; in both Plain and Ornamental patterns; vertical and horizontal forms.
- 7 sq. ft. Section; 24"x12½"x3"; in both Plain and Ornamental patterns; vertical and horizontal forms.
- 6 ft. sq. Section; 21"x12½"x3"; in both Plain and Ornamental patterns; vertical and horizontal forms.
- 5 sq. ft. Section; 17"x12½"x3"; in both Plain and Ornamental patterns; vertical and horizontal forms.
- 3¾ sq. ft. Section; 17"x9½"x3"; in both Plain and Ornamental patterns; vertical and horizontal forms, but assembled in vertical form only.



The construction of Fowler & Wolfe Wall Radiators, embracing large cross and smaller intersecting tubes, (originated and patented by us), insures effective circulation, therefore high efficiency, in whatever form assembled or used.

All of our radiation is tested twice before shipment at 100 lbs. water pressure. For steamship and special service, it may be tested, specially, at water pressures up to 250 lbs.; and on special order, can be furnished in extra heavy sections to withstand water pressures up to 400 lbs.

It can be installed in bay windows of practically any angle, by means of special ells which we carry regularly in stock and can be curved, by mitering, to conform to any circular window or space of a radius not less than six feet.

Our No. 30 Adjustable Hanger (illustrated), has swinging hook providing for expansion and contraction of radiator and is adjustable, upward or downward, one inch, by means of a set screw, such adjustment being possible after the radiator is erected. Top of hanger is cross slotted for head of tie bolt, to hold the top of the radiator securely.

This Hanger is made to accommodate all forms and makes of Wall radiation, and, by the use of special hooks, Single Column and Two Column radiators.

Length of Hanger 17¼ in. Weight 6 lbs. 5 oz. Distance from bottom of Hanger to bottom of radiator, (when hook is at lowest point), 4¾ in. Distance from wall to back of radiator 1¼ in.

Our catalogue "F" fully illustrates and describes our radiators and, for supporting same, an extensive variety of Hangers, (adjustable and non-adjustable), Supports, etc. to meet practically any requirement.



Minnesota Radiator Co.

Plant and Home Office:
Duluth, Minn.

Manufacturers of Minnesota Radiators
"Standard of the Northwest"



Measurements of Sections and Tappings	One Col. All Heights	Two Col. All Heights	Three Col. All Heights	Four Col. 44, 38, 26, 22, 18"	Four Col. 16"	Four Col. 20"	Five Col. 18, 16, 13"
Wid h in.	4½	7½	9	12	12	13	13
Wid h Leg in.	5½	7½	9½	12½	12½	13½	13½
Thickness in.	2½	2½	2½	2½	2½	3	3
D *	5	5	5	5	3	5	3
Distance from floor to center of upper tapping, inches							
45 in.		41½	41½	41½			
38 in.	36½	35½	35½	35½			
32 in.	30½	29½	29½	29½			
26 in.	24½	23½	23½	23½			
23 in.	21½	20½	20½				
22 in.				19½			
20 in.	18½	17½	17½			17½	
18 in.				15½			15½
16 in.				13½	13½		13½
13 in.							10½

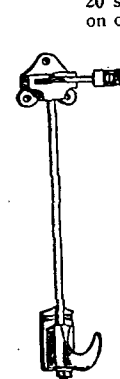
*D is Distance from floor to Center of Tapping Supply and Return, Inches. Allow ½ in. for each bushing. Center legs on radiators of 20 section in 5 col. and 25 sections on one, two, three and four column.

Miraco Hangers

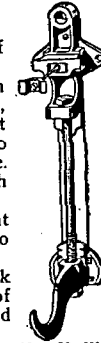
for any make of Radiators.

Fastens to wall with one bolt (or more), side adjustment at top and bottom. No labor to assemble. No bolts to furnish or pipe to cut. Vertical adjustment at bottom easy to make.

Our solid steel back avoids breaking of plaster on furred walls.



No. 2632 Col.



No. 79 Wall

No. 2632 for 26" and 32" Col. Radiation.....\$1.35
No. 3845 for 38" and 45" Col. Radiation..... 1.45
No. 79 for 7" and 9" Wall Radiation..... .90

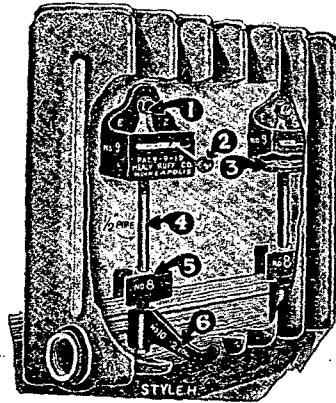
Healy-Ruff Company Minneapolis, Minn.

AGENTS IN THE FOLLOWING CITIES:

Amsterdam, N. Y., Boston, Buffalo, Chicago, Cincinnati, Cleveland, Columbus, Davenport, Denver, Des Moines, El Paso, Indianapolis, Kansas City, Knoxville, Los Angeles, Milwaukee, New Orleans, New York, Oakland, Omaha, Rochester, Rocky Mount, N. C., St. Louis, Salt Lake City, Seattle, Syracuse, Wichita.

CANADA—Calgary, Halifax, Montreal, Ottawa, Toronto, Vancouver, Winnipeg.

Manufacturers of E-Z Radiator Hangers



1. One Bolt
2. Invisible Washer
3. Horizontal Adjustment
4. Vertical Adjustment
5. Adjustable for Baseboard
6. Made for Wall, and Column Radiation

E-Z Radiator Hangers are suitable for Wall and all Column Radiation, are designed for Vertical and Horizontal alignment, and also designed to anticipate the use of temperature control valves.

Washer at top makes hanger absolutely invisible.

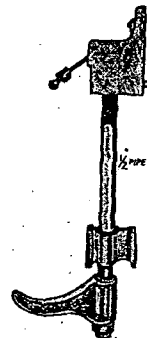
Style "H" shown above, places the radiator 2 1/2" from the wall and provides for baseboard adjustment.

Style "R" places the radiator 1 1/2" from the wall but is not adjustable for baseboards.

Typical Specifications

Where Baseboards are used.

All radiation, unless otherwise noted, shall be supported on wall by means of

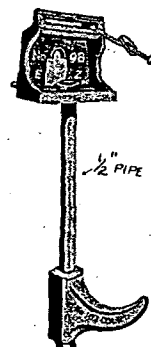


Style H

E-Z Radiator Hangers, Style "H," as manufactured by the Healy-Ruff Company, Minneapolis, Minnesota, or equal and approved in writing by the Architect, arranged to support the radiator 2 1/2" 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 Company, Minneapolis, Minnesota, or equal and approved in writing by the Architect, arranged to support the radiator 1 1/2" inches from the wall.



Style R

Sarco Co., Inc.

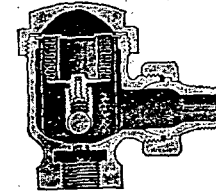
Woolworth Building, New York

Buffalo, Philadelphia, Cleveland, Detroit, Chicago, Boston

Radiator, Blast and Steam Traps, Temperature Control

Sarco Radiator Traps

The Sarco Radiator Trap, type "E," is a development of the Sarco Steam Trap used everywhere for high and low pressure. It is factory adjusted and can be used on vapor or vacuum heating systems, any degree of vacuum or any pressure up to 20 pounds. Absolutely no adjustment necessary. The thermo-element consists of a spirally corrugated tube large in diameter within which is contained a volatile liquid under vacuum. The expansion element is suspended from the body and held in place by the cap.



Type "E"

One end of valve stem is fastened to expansion head; other end carries socket holding free revolving ball valve head. A cylinder strainer is fitted to body.

When steam is off, the valve is open. When steam comes in contact with outside of thermo element the volatile liquid is vaporized and the vapor pressure moves the valve downward to its seat. Valve remains closed until condensate reaches the trap, causing volatile liquid to condense and open valve. Steam closes valve and the cycle is repeated whenever condensate collects.

The Sarco Radiator Trap is made in two sizes, 1/2" and 3/4", capacities up to 200 and 800 square feet direct C. I. radiation, respectively.

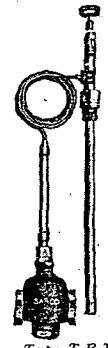
SARCO RADIATOR TRAP SPECIFICATIONS

Size, inches	1/2	3/4
Length over all inches	3 3/4	3 3/4
Distance, center of Inlet to face of Outlet, inches	1 1/2	1 1/2
Distance, center of Valve to face of Outlet, inches	2 3/4	2 3/4

Write for Steam Trap Bulletin

Sarco Temperature Regulators

For maintaining a constant temperature of liquids and atmosphere. Substantially constructed on same thermostatic principle as the steam trap Sarco (not illustrated or described here; full particulars furnished on request).



Type T.R. 21 for Air Ducts and Tanks

OPERATION—Slight increase in temperature of surrounding liquid or atmosphere expands operating fluid, producing a powerful hydraulic pressure tending to close valve; a decrease in temperature contracts fluid, and gradually opens valve.

Sarco regulators operate steam, water or gas valves.

USES—They are being widely adopted and are suitable for public institutions, schools, hotels, packing houses, canning factories, bottling works, paper mills, gas condensers and producers, ammonia stills, hot water service tanks, blast heaters, etc.

Temperature Control Specifications

Size In.	Weight Lbs.	Face to Face of Valve, In.	List Price T. R. 21	List Price K. R. 14
1/2	7	2 1/2	\$75.00	\$60.00
3/4	7	2 3/4	80.00	65.00
1	9	3 1/2	85.00	70.00
1 1/2	13	4 1/2	90.00	75.00
1 3/4	22	5	95.00	85.00
2	28	6	100.00	95.00
2 1/2	37	7 1/2	115.00	110.00
3	51	8 3/4	130.00	125.00
4	81	13 1/2	170.00	165.00
5	132	15 3/4	225.00	215.00
6	158	18	275.00	265.00

Write for description of New
SARCO THERMOMETERS

Carrier Construction Company

750 Frelinghuysen Ave.

Newark, N. J.

SHEET METAL ARTISANS
Design, Fabrication and Installation

Light Machine Work, Acetylene and Electric Welding.
Special Work requiring Unusual Facilities and Expert Workmanship.
Carrier Diffuser Outlets and Aertite Doors.

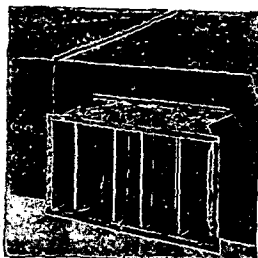
The Carrier Construction Company is equipped with every facility for the fabrication and installation of sheet metal work, light machine work, acetylene and electrically welded work, pipe work, and special apparatus involving work of this general character.

We are not in position to accept contracts for standard pieces, except in large quantities, nor do we solicit small repair or maintenance work. But we are especially well fitted to undertake new work of special nature, such as duct systems for heating and ventilating installations; exhaust systems for buffing and grinding wheels, and for the removal of shavings, dust, fumes, gases, or vapors; collecting systems; and similar work involving the fabrication of sheet metal up to 1/4-inch plate—and heavier in certain instances.

We are experienced in design as well as construction, so that we can undertake to collaborate with the client in the fabrication of special apparatus.

We invite correspondence and we will be glad to send descriptive catalog upon request.

We manufacture in quantity, for sale to the trade, the **Carrier Diffuser Outlet** and the **Carrier Aertite Door**. Both are die-stamped of best galvanized metal and furnished ready for installation.



The Aertite Door is neat, strong and air-tight. It adds greatly to the appearance of the job and is so easily installed, by merely clinching the flanges, that the saving in labor practically pays for the door. Made in three sizes, 10"x16", 16"x24" and 24"x36".

The scientifically designed Diffuser Outlet, with adjustable volume vanes, not only improves the appearance of the whole job, saves labor and installation expense, but affords uniform air diffusion over entire area of outlet, at any degree of opening. Made in five sizes, 9"x10", 10"x15", 15"x15", 15"x21" and 15"x27".

Prices upon request. Prompt delivery from stock.

AMERICAN DISTRICT STEAM COMPANY

GENERAL OFFICES AND WORKS

NORTH TONAWANDA, N.Y.

Adscos System of Steam Heating and Adscos Heating Specialties

Adscos System of Atmospheric Steam Heating

Unusually economical whether steam supply is from Individual Boiler or from Central Station; requires no radiator traps, vacuum pumps or other complicated devices; operates under atmospheric pressure—return lines being vented to the atmosphere.

Adscos Graduated Radiator Valve

Made in 3/4" size only to supply steam to the specific amount of radiation in all standard sizes of radiators up to the equivalent of 200 sq. ft. of direct radiation with 5 ounces steam pressure at the valve. Made in three designs—Handwheel, Lever Handle or Lock and Shield. The valve is so calibrated that with radiation properly set and with 5 ounces pressure at the valve, 80% of the radiator will be filled with steam when the valve is wide open, the lower portion of the radiator acting as "economizer surface" to extract the heat from the condensate before it passes off into the return lines.

The valve opens fully with a three-quarter turn of the handwheel or lever handle and a pointer plainly indicates the position of the valve so that the operator knows at a glance to what proportion the valve is open. With this arrangement the operator can control at will the amount of radiating surface to be filled with steam.

To make the valve interchangeable for all sizes of radiators, it is provided with a graduated disc in the outlet, which is marked with the amount of radiation to be supplied and which is readily interchangeable for different amounts of radiation.

Adscos Damper Regulator

This regulator consists of a weighted copper float incased in a cast iron shell which is tapped for 3/4-inch connection at top and 1 1/4-inch at bottom. The bottom opening is for connection to the boiler

below the water line, and the top opening for connection to the vent from the system.

Adscos Union Elbow

This elbow is used for discharge connection on all radiators, no valve or return traps of any kind being required on the return connection in the ADSCOS SYSTEM. The elbow is 3/4" in size for all radiators.

Adscos Safety Valve

Provides quick relief for excess boiler pressure, resulting from leaving the ash-pit door open or from other accidental causes. The valve is set at the factory to blow off at 18 ounces pressure, and is then sealed. It can easily be adjusted for lower pressures of 15 and 13 ounces. The boiler connection is 1 1/4".

Adscos Mercury Gauge

This gauge is specially designed for indicating pressures on the ADSCOS System and should be connected to the main steam supply pipe, or if desired may be installed in a convenient location on any supply riser. The pipe connection is 1/4".

Engineering Data

Ask for Bulletin No. 159-VE for information as to arrangement of piping, proper pipe sizes to install for various amounts of radiation, also other valuable and interesting facts regarding vapor heating.

Other Adscos Products

For use in construction of underground steam distribution lines: Expansion joints, crosses and tees, expansion variators, Duplex Sleeve Guided Type expansion joint for superheated steam, condensation meters, St. John Steam Pressure meters, steam pipe casing, also flanged fittings.

For data regarding heating a group of buildings from a Central Heating Plant ask for Bulletin No. 20-VE.

C. A. Dunham Co.

Administrative and General Offices: 230 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 York, 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, Halifax, Montreal, Ottawa, Toronto, Winnipeg, Vancouver

FOREIGN SALES OFFICES:

London, England
233 A Regent St., W. I.
St. John's Newfoundland
406 Water Street
Paris, France
64 Rue du Rocher

Manufacturers of Specialties for The Dunham Systems of Heating

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.

These specialties are Dunham Radiator Traps; Dunham Blast Traps; Dunham Air Line Valve; Dunham Return Traps; Dunham "D" Style Medium Pressure Traps; Dunham Packless Radiator Valves; Dunham Reducing Pressure Valve; Dunham Vacuum Pump; Dunham Vacuum Pump Governor; Dunham Air Eliminator; Dunham Oil Separator; Dunham Suction Strainer; Dunham Air Vent; Dunham Damper Control.

The DUNHAM HEATING SERVICE

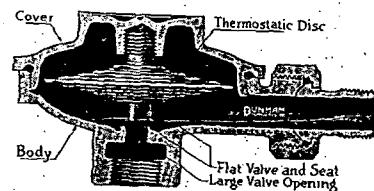
Dunham Service is: First, Advisory—when making contact and soliciting business. Second, Supervisory—during construction period. Third, Adjustive—in the sense of rendering aid to the user.

This Service is delivered through 52 Branch and Local Sales Offices throughout the United States and Canada, back of which organization are two modern and complete factories. Dunham Heating Service co-operates intimately with Consulting Engineers, Architects and Heating Contractors.

Dunham Radiator Trap

The Dunham Radiator Trap is distinctive in the simplicity of its construction. It consists of two major parts, a body and a cover. The operating member, the

Thermostatic Disc, is securely placed in the cover. The Trap has a large valve opening. There are no detached loose parts in the path of flow, nor sliding contacts, nothing to gum up, and no guide or pin to obstruct the valve opening. The action of the disc is positive and the valve seats squarely. The body is standardized, also the cover and disc, giving the further advantage of interchangeable parts.



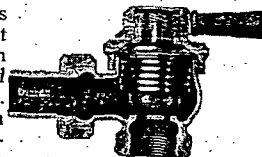
The working part of the Trap, the Thermostatic Disc, is fully exposed to the actual conditions within the radiator and it, therefore, responds instantly to any change taking place therein, preventing waste of unused steam.

It is made in five sizes and for varying pressures not to exceed ten pounds gauge.

Dunham Packless Radiator Inlet Valve

This is a bona fide Packless Valve and not dependent upon springs and packing rings.

The Dunham "built up" bellows makes this possible. The expansion member is a made-up diaphragm constructed of special phosphor

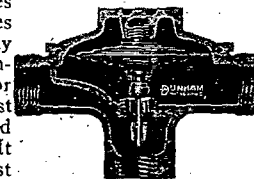


bronze formed under pressure. The curves of the corrugations are especially designed to uniformly distribute the motion over the several flat surfaces of the member. This admits of more motion for a given length. It is strongest where strength is needed and has great flexibility. In manufacture the metal is not weakened by excessive strains. In being formed to shape, its elasticity is increased. A distinct feature is the distance between the folds, which is sufficient to make the entire member self-cleaning. It is a valve of unusual lines, making it attractive in appearance. The valve can be opened or closed in seven-eighths of a turn.

It is now made in patterns for use at top or bottom radiator connection.

Dunham Medium Pressure Trap "D" Style

This embodies the principles so successfully used in the Dunham Radiator Trap, and is just as simple and satisfactory. It is used almost exclusively in hospitals and kitchens for dripping sterilizers and steam cooking apparatus, where steam is used at a pressure of more than ten (10) pounds and less than fifty (50) pounds gauge.



Dunham Air Line Valve

An automatic air valve for use on radiators, but only in connection with air line piping into which it must discharge. Positive in action, opening for passage of air, and closing against steam. Non-adjustable. Its principle of operation is identical with the Dunham Radiator Trap.

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, not over eight ounces. 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. 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.

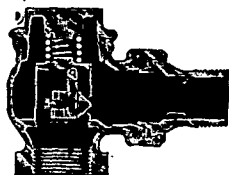
Bulletins

Bulletins of standard architectural size with detailed information covering each System, and all products, including roughing-in dimensions, will be furnished on request.

Donnelly Systems Co.

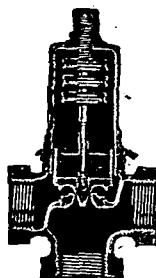
9 Murray Street
New York, N. Y.

Temperature Control by Fractional Damper Regulators and Fractional Distribution Valves. Impulse Check Valves, Thermo-Differential Valves, and other Specialties for One and Two-Pipe Systems, Vacuum Return Line Systems, Gravity and Forced Hot Water Circulation Systems.



The practical and theoretical experience of 37 years has developed the Donnelly Systems and the Donnelly Specialties.

orifice being such that a complete discharge of the air and water is at all times effected and a constant difference in pressure between the branch steam and return lines of one-half pound is always maintained.



The entire operative mechanism of the Impulse Valve is enclosed in a heavy removable tube which is inserted in a standard valve body and the valves are guaranteed for five years.

The Thermo-Differential Valve, used in Vacuum Return Line Systems is constructed as shown. It is made with a standard safety valve body and has a restricted seat which is proportioned to the capacity of the valve. The valve disc is provided with an impact surface, as in the Impulse Valve, and with a cup-shaped portion for holding the weights, together with a central rod which acts as a guide for the vaporizing fluid thermostat. The opening in the bottom of the valve is intended as a cleanout and should be provided with a nipple and cap. A small leakage opening is provided in the seat so that the system will drain when shut down.

A Thermo-Differential Valve is installed in each branch return so that no water, air or steam can pass into the main return without being properly regulated in pressure and flow.

We will be glad to furnish catalogs or leaflets completely describing our specialties and their applications.

The general theory of design and control of the steam circulation in all Donnelly Systems is based upon the recognized principle that in small systems there are, for short runs and for a limited number of automatic return valve devices, no appreciable differences or losses in pressure. In other words, small systems have always proved simpler and more satisfactory in operation than larger systems.

Therefore all Donnelly gravity and vacuum return line plants are divided into groups of convenient and restricted size. The former are provided with a Thermo-Float Air Valve and the latter with a Thermo-Differential Valve for each group.

The early recognition of this principle led to the design of the Impulse Check Valve, which is used at the return outlets of all radiators and coils in all Donnelly Systems, preventing any water or steam from entering the radiator from the return piping.

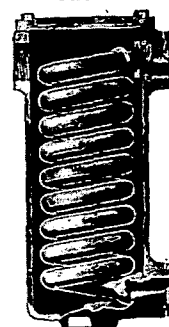
It is an Automatic Needle Valve, the size of the orifice through the seat being properly proportioned to the pipe size and to the rated capacity of the valve. The normal operation of the valve is the same in all systems, the weight over area of the disc and the size of the

Excelso Specialty Works

119 Clinton Street
Buffalo, N. Y.

Excelso Indirect Water Heater, Fire Pot Generators, Rotary Hack Saw Tools

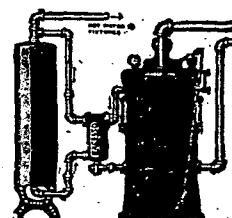
The Excelso Water Heater



consists of a heavy copper coil heating element fitted in a cast iron shell by means of patented ground joint connections. All parts are interchangeable and easily accessible.

Connected on the outside of steam or vapor boilers the Excelso eliminates the fire pot coil and insures a constant supply of domestic hot water all during the heating season at an even temperature.

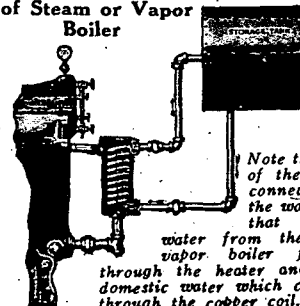
The Excelso method generating domestic water is so satisfactory and the expense so trifling that boiler manufacturers are providing special tappings in their boilers and heating engineers generally are recommending its use.



Shows Excelso connected to round type of steam or vapor boiler. The storage tank may be located either in basement or any floor above.

The Excelso Heater can be easily connected below the water line of any steam or vapor heating boiler in any new or old installation. Also used for heating water or other liquids with live steam up to 25 pounds.

Typical Installation of Steam or Vapor Boiler



Note that the shell of the Excelso is connected below the water line and that the boiling water from the steam or vapor boiler flows down through the heater and heats the domestic water which circulates up through the copper coil.

Dimensions—Price List—Capacities

Size of Heater	11	12	13	14	15
Length, in.	10½	14	11½	15	19½
Diameter, in.	5	5	6½	6½	6½
Shell openings 1"	1"	1"	1¼"	1½"	1½"
Coil openings ¾"	¾"	¾"	1"	1"	1"
Weight, lbs.	17	23	31	39	46
List Price	\$30	\$40	\$50	\$60	\$70

Heating Water Below Water Line of Steam or Vapor Boilers

Size of Heater	11	12	13	14	15
Tank Capacity	30	45	60	90	120
Temperature rise	100 degrees in 3 hrs.				

Heating Water With Live Steam

Size of Heater	11	12	13	14	15
Tank Capacity	50	75	100	150	200
Temp. rise 100°-3 hrs.	5 lbs. pres.				

Instructions for Ordering Heaters

Many tanks are installed too small and heaters should always be ordered to correspond with work required and not size of tank. Also make liberal allowance if circulating system is used.

Excelso Rotary Hack Saw Tool

Boilers may be easily and quickly tapped by means of the Excelso Rotary Hack Saw Tool.

Each Tool cuts holes for either 1", 1¼" or 1½" pipe tap. Price, \$7.50 net, including 6 blades, 2 of each size.



Excelso Fire Pot Generator



Pot Generator fits any type hot water boiler or hot air furnace and is so designed as to be entirely above fire.



Made in two sizes and in both cast iron and brass.

Size No. 1. Up to 40 gal. capacity.

Size No. 2. Over 40 gal. capacity.



Sectional View

Hoffman Specialty Co., Inc.

Waterbury, Conn.

Boston New York Philadelphia Chicago Los Angeles

Hoffman Controlled Heat
Hoffman Venting, Modulating and Thermostatic Valves
Hoffman Differential Loops

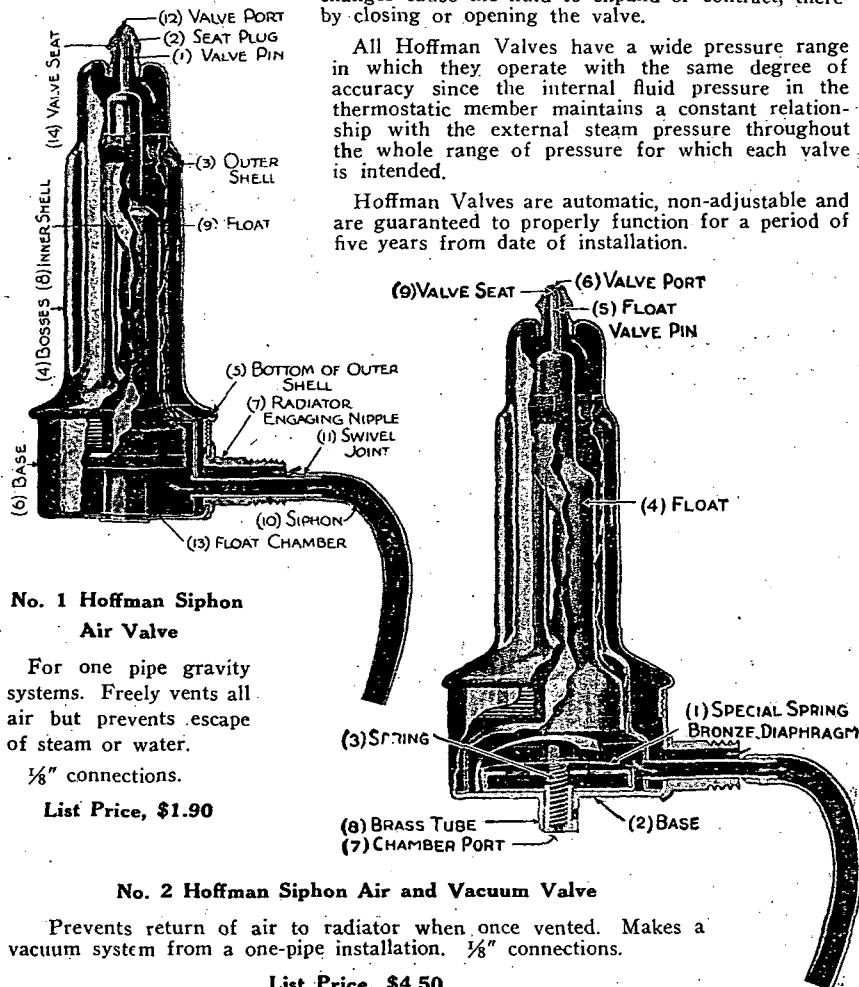


In the Hoffman Series of Air Vents there is a specially designed valve for every type of steam heating.

The basic principle embodied in the design of all Hoffman Ventilating and Thermostatic Valves is that of an all-metal thermostatic member, having one or more flexible diaphragms, and containing a volatile or heat-sensitive fluid. Slight temperature changes cause the fluid to expand or contract, thereby closing or opening the valve.

All Hoffman Valves have a wide pressure range in which they operate with the same degree of accuracy since the internal fluid pressure in the thermostatic member maintains a constant relationship with the external steam pressure throughout the whole range of pressure for which each valve is intended.

Hoffman Valves are automatic, non-adjustable and are guaranteed to properly function for a period of five years from date of installation.



No. 1 Hoffman Siphon Air Valve

For one pipe gravity systems. Freely vents all air but prevents escape of steam or water.

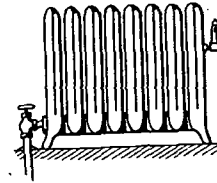
$\frac{1}{8}$ " connections.

List Price, \$1.90

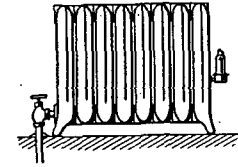
No. 2 Hoffman Siphon Air and Vacuum Valve

Prevents return of air to radiator when once vented. Makes a vacuum system from a one-pipe installation. $\frac{1}{8}$ " connections.

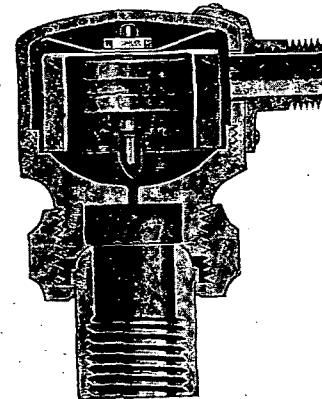
List Price, \$4.50



Correct application Nos. 1 or 2 Hoffman Valve for one-pipe gravity or vacuum steam heating, on steam-type radiators.



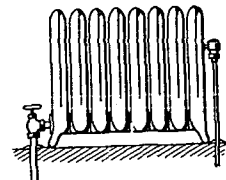
Correct application Nos. 1 or 2 Hoffman Valve for one-pipe gravity or vacuum steam heating, on water-type radiators.



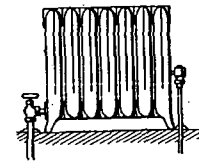
No. 3 Hoffman Air Line Valve

For use in Air Line Systems of Paul type. A hot radiator and cold air line always maintained. $\frac{1}{8}$ " male connection— $\frac{1}{4}$ " female connection.

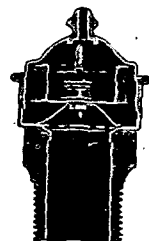
List Price, \$2.50



Correct application No. 3 Hoffman Valve for Air Line gravity or vacuum steam heating, on steam-type radiators.



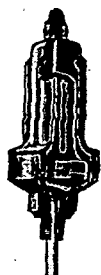
Correct application for No. 3 Hoffman Valve for Air Line gravity or vacuum steam heating, on water-type radiators.



No. 4 Hoffman Quick Vent Valve

For quick venting mains, blast coils or for any service where water is not a factor. Vent port $\frac{1}{8}$ " dia. Pipe connection either $\frac{1}{4}$ " or $\frac{1}{2}$ ".

List Price, \$2.80



No. 5 Hoffman Quick Vent Float Air Valve

Permits quick vent in return line vapor systems or for service where water is encountered and must not be permitted to pass through the vent port. Pipe connections $\frac{1}{8}$ ". Specify $\frac{1}{8}$ " port for pressures of 3 lbs. or over; $\frac{1}{16}$ " port for less than 3 lbs.

List Price \$8.00



No. 6 Hoffman Quick Vent Float Air and Vacuum Valve

Is adapted for venting return lines and for other service where return of air to the system is not desirable. Pipe connections $\frac{1}{8}$ ". Specify $\frac{1}{8}$ " port for pressures of 3 lbs. or over; $\frac{1}{16}$ " port for less than 3 lbs.

List Price, \$12.00

The No. 4 Hoffman Valve is suitable for venting steam or vapor lines, when water is not encountered, nor vacuum required.

The No. 5 Hoffman Valve is suitable for venting steam or vapor lines where water might be encountered. The No. 5 valve will freely vent air and close against steam or water.

The No. 6 Hoffman Valve operates the same as No. 5 valve except that it closes after venting air, preventing return of air to the system.

Fig. 1 shows correct application of Nos. 4, 5 or 6 Hoffman Valve for venting end of steam or vapor main.

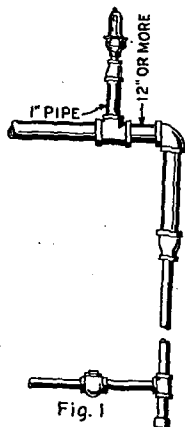


Fig. 1

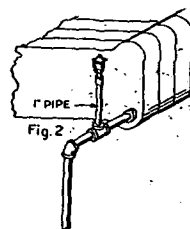


Fig. 2 shows correct application of Nos. 4, 5 or 6 Hoffman Valve for venting indirect radiator.

Fig. 2

Fig. 3 shows correct application of Nos. 5 or 6 Hoffman Valve for venting False Water line loop, providing by-pass for draining or cleaning.

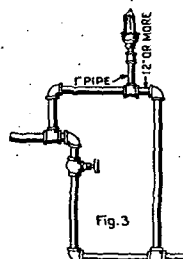


Fig. 3

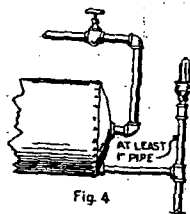
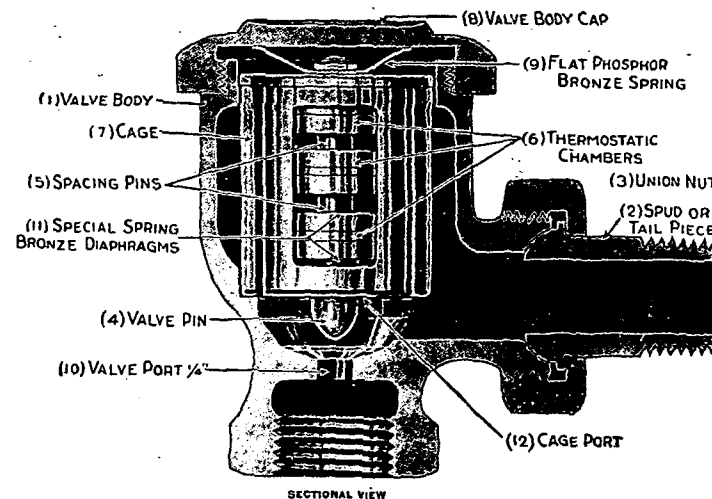


Fig. 4

Fig. 4 shows correct application of Nos. 4, 5 or 6 Hoffman Valve for venting steam coil in storage tank.



HOFFMAN RETURN LINE VALVES

No. 8 and No. 9

Special Operative Features

The Hoffman Return Line Valve positively distinguishes between steam, air and water, freely passing the air and water but stopping the steam. It is non-adjustable. The thermostatic parts are interchangeable and may be shifted from one valve body to another of the same size without affecting the proper operation of the valve. Under atmospheric conditions the thermostat is set to maintain a wide open valve at 200 degrees Fahr., but, when steam, under atmospheric conditions (i. e., no pressure) but with a temperature of 212 degrees reaches the valve the thermostat fully and completely expands, tightly closing the exhaust port of the valve.

One of the chief features of the Hoffman Return Line Valve is its consistency of operation within a pressure range of from 13" vacuum to 50 pounds pressure. Within this range, condensation at a temperature of 10° to 12° less than the temperature corresponding to the steam pressure will cause a full valve opening.

In determining the valve capacity for blast coils the condensing power of such coils should be calculated on the basis of being four to eight times greater than radiator cast iron surface, the minimum outside temperature determining which factor to use.

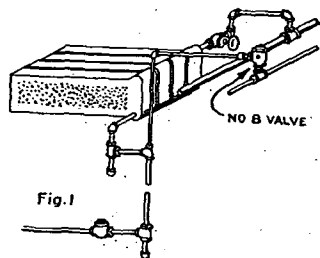


Fig. 1 shows application of No. 8 and 9 Hoffman Valves for venting and dripping indirect radiator into gravity or vacuum return line.

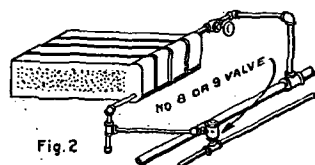


Fig. 2 shows application of No. 8 Hoffman Valve for venting indirect radiator into air line, dry or vacuum return.

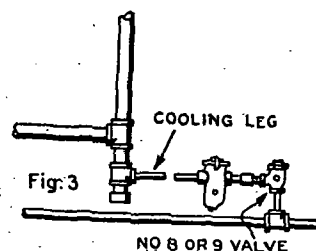
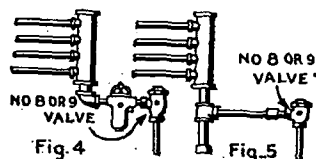


Fig. 3. Dripping heel of riser thru dirt strainer and venting thru No. 8 or 9 Hoffman Valve into gravity or vacuum return. Cooling legs wherever shown must not be less than 5 feet long.



Figs. 4 and 5 show proper application of No. 8 or 9 Hoffman Valves for dripping coils. Dirt strainers should be used when steam pressure exceeds 5 pounds.

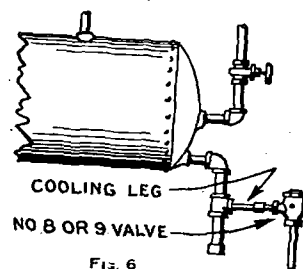
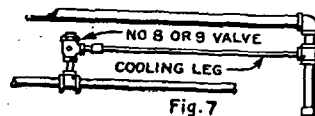


Fig. 6 shows the proper application of No. 8 or 9 Hoffman Valves for dripping storage tank coils into gravity or vacuum return. Cooling leg to be at least four feet or more in length.



Figs. 7 and 9 show typical methods of dripping ends of mains or branches into gravity or vacuum returns, thru No. 8 or 9 Hoffman Valves. Cooling leg to be at least four feet or more in length.

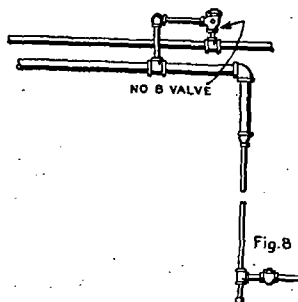


Fig. 8 shows application of No. 8 Hoffman Valve for venting end of steam main into dry return.

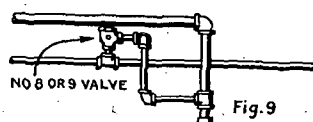


Fig. 9



The No. 7 Hoffman Adjustable Modulating Radiator Supply Valve is used at the supply end of a direct radiator to control the heat. Made in $\frac{3}{4}$ " size for use on radiators up to 200 sq. ft. capacity.

The No. 7 Hoffman Adjustable Modulating Valve, as shown, has a Top Dial Plate, a Lower Dial Plate and a Rotary Sleeve.

The Top Dial Plate is attached to the Rotary Sleeve and is movable when the Lock Nut is loosened; the Lower Dial Plate is stationary and has 20 Graduating Marks, which, when exposed to view, indicate that the opening in the Rotary Sleeve corresponds to the area of the Outlet Port in the body of the valve. When the Lock Nut is loosened and the Top Dial Plate turned by means

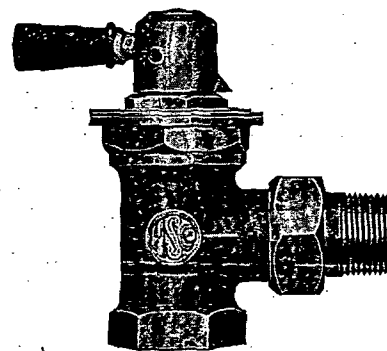


Top of Hoffman Modulating Valve showing Graduated Dial

of the handle, the Rotary Sleeve gradually diminishes the Outlet Port area.

When the 20 Graduating Marks are exposed to view, the Outlet Port area is sufficient to supply vapor for 200 square feet of radiating surface in 70° room temperature with two ounces pressure at the radiator. With a decrease in the number of Graduating Marks exposed to view, the Outlet Port is correspondingly diminished, so that when 15 Graduating Marks show, the Outlet Port will pass sufficient vapor to supply 150 square feet of radiation; 10 Graduating Marks, 100 square feet; 5 Graduating Marks, 50 square feet.

The Top Dial Plate is graduated in quarters from "SHUT" to "OPEN." As the handle is turned from "SHUT" to "OPEN" the valve disk is raised, uncovering the portion of the Outlet Port indicated by the fractional graduation on the Top Dial Plate.



Hoffman Modulating Valve with Lever Handle
List Price, \$6.00

NO. 7 HOFFMAN MODULATING VALVE



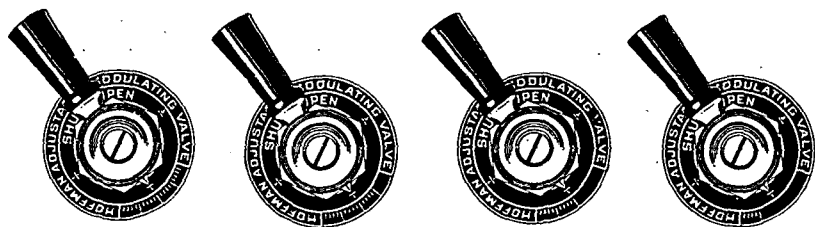
To Specify By Name:

Furnish and install on the supply end of each radiator, a No. 7 Hoffman Adjustable Modulating Valve, equipped with Jenkins Disk and Rotary Sleeve.

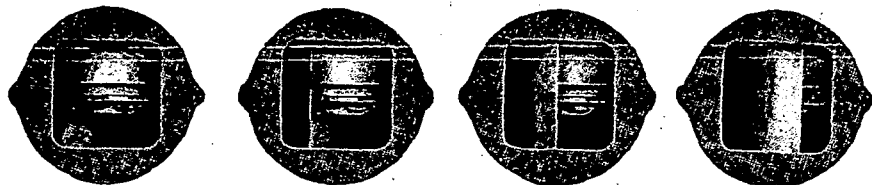
To Specify By Description:

Furnish and install on the supply end of each radiator a $\frac{3}{4}$ " rotary sleeve, graduated, leakless, valve, made of best steam metal, rough body, finished trimmings, nickel plated all over, and equipped with lever handle, Jenkins disk and union. Valve to be fitted with dials indicating port area and fractional control.

Also furnished with Wood Wheel Handle, Lock Shield with Removable Key and Extension Stems and Handles.



All Marks exposed	15 Marks exposed	10 Marks exposed	5 Marks exposed
200 sq. ft.	150 sq. ft.	100 sq. ft.	50 sq. ft.

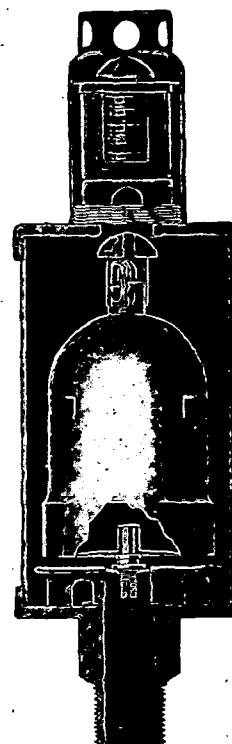


The No. 10 Hoffman Vapor Valve

positively distinguishes between air, steam and water, freely venting the air no matter whether this air is hot or cold but instantly closing against the pressure of steam. It also closes tight against water leakage when water comes against the valve but opens wide for the free passage of air at pressure less than one pound and opens its $\frac{1}{8}$ " port the instant the water drops away from it at pressure of 5 pounds or less.

It is automatic, non-adjustable and dependable in all the functions it is designed to meet.

List Price, \$25.00



No. 10

The No. 11 Hoffman Vapor Valve

operates the same as the No. 10 Vapor Valve except that it is provided with a vacuum valve, as shown, which prevents the return of air to the system when once vented.

List Price, \$28.00



No. 11



The Hoffman Differential Loop

is a safety device, Automatic, Non-Adjustable, made entirely of metal without moving parts or mechanical device of any kind.

On a properly designed installation it should never function. It is the watchman of the water line always on guard and makes vapor heating safe because it insures a constant unvarying boiler water line by maintaining a fixed pressure differential of 10 oz. between the main steam line and the return air line of the "Vapor Heating System" when the boiler pressure is above 10 oz.

No cracked boiler sections—where the Hoffman Differential Loop is used.

The sectional cut clearly shows the mechanical construction of the Differential Loop.





The Operation of the Hoffman Differential Loop

is peculiar, inasmuch as it absolutely maintains an unvarying water line in the boiler, independent of boiler pressure, that is no matter whether the boiler pressure is 8 oz. or 5 lbs. the water line in the boiler will maintain at a constant level. It also maintains, when the boiler pressure is more than 10 oz. a fixed pressure difference of 10 oz. between the main steam line from the boiler and the main air return line from the radiators. In other words the pressure in the steam main is always 10 oz. ahead of the pressure in the return line when the boiler pressure is above 10 oz. The maintenance of this pressure difference between the steam main and the return line insures a continuous flow of steam into and through the radiators. It also means that should an out-of-service radiator be put into service when the boiler pressure is 1 lb. or over, that this radiator will heat just as quickly under boiler pressure of 1 lb. or over as it will when boiler pressure is maintained at 8 oz. because the pressure at the inlet valve is 10 oz. more than the pressure at the outlet valve.

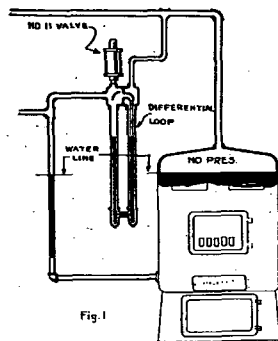


Fig. 1

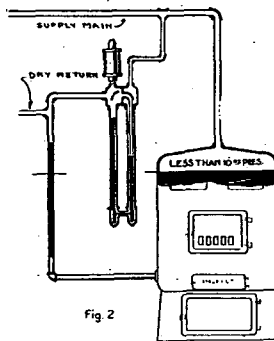


Fig. 2

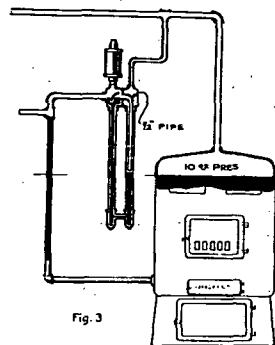


Fig. 3

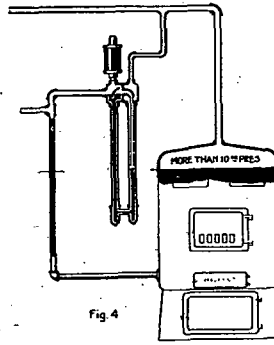
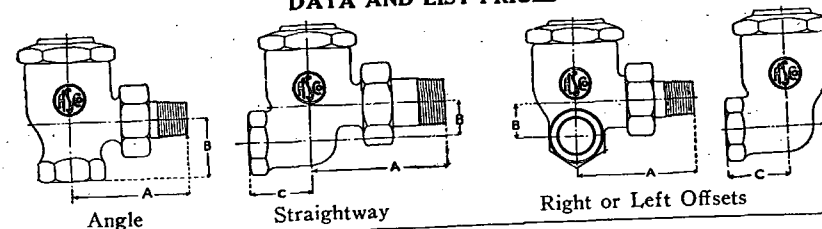


Fig. 4

DATA AND LIST PRICES



Style	Size	Diameter Valve Port	Maximum Capacity Square Feet	A	Dimensions B	C	List Price
No. 8 Angle.....	1/2"	1/4"	200	2 3/4"	1 3/4"		\$6.00
No. 8 Straightway.....	1/2"	1/4"	200	2 3/4"		1 3/4"	6.00
No. 8 Offset.....	1/2"	1/4"	200	2 3/4"		1 3/4"	6.00
No. 9 Angle.....	3/4"	3/8"	600	3 3/4"	1 1/2"		8.00

*No. 9 Valve furnished with 1/8" Port for pressures above 15 lbs.

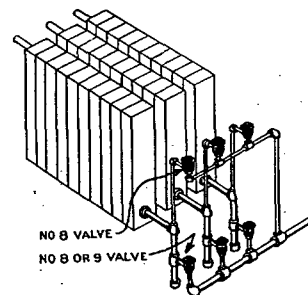


Fig. 1

Figs. 1 and 2 show application of Nos. 8 and 9 Hoffman Valve for venting Blast Heaters into gravity or vacuum returns.

Fig. 3 shows application of No. 9 Hoffman Valve for draining and venting sterilizer in gravity or vacuum return.

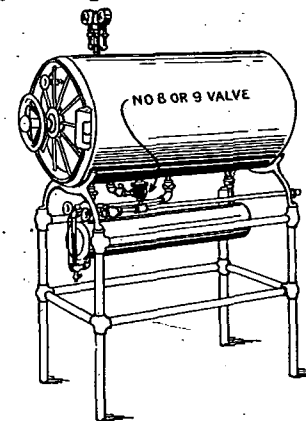


Fig. 3

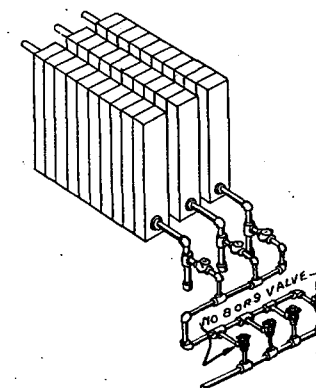


Fig. 2

Fig. 4 shows application of No. 9 Hoffman Valve for dripping steam or cooking kettles into gravity or vacuum return.

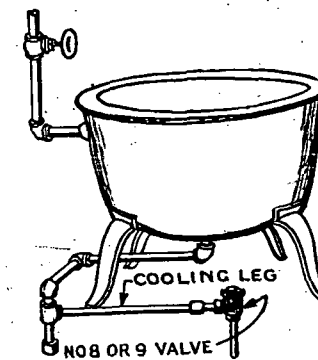
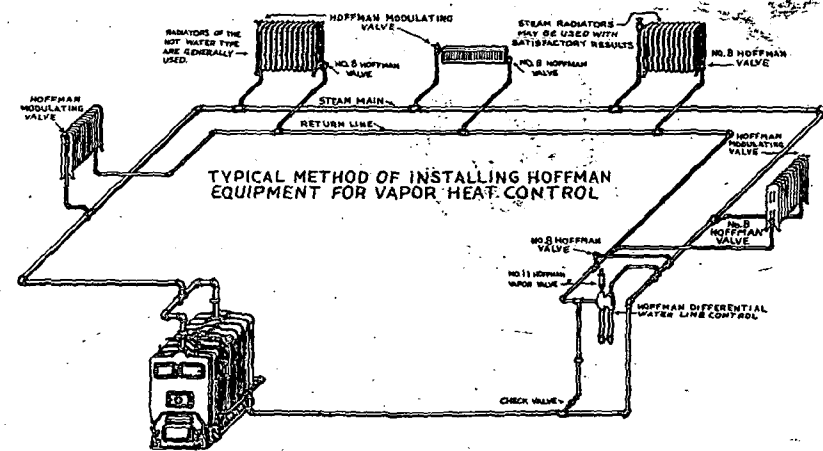
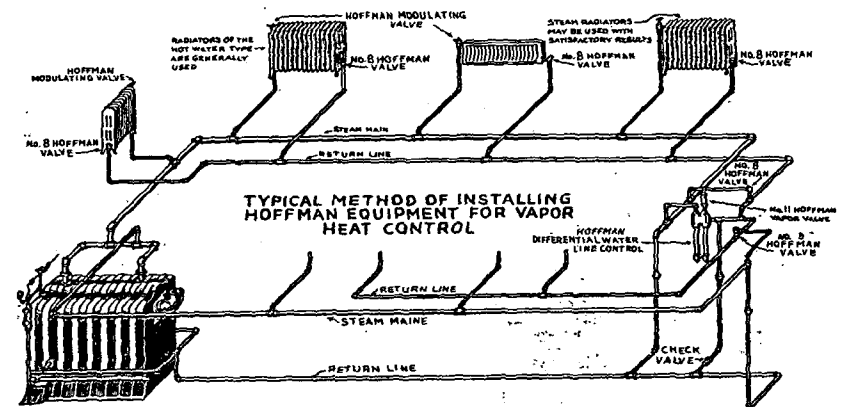
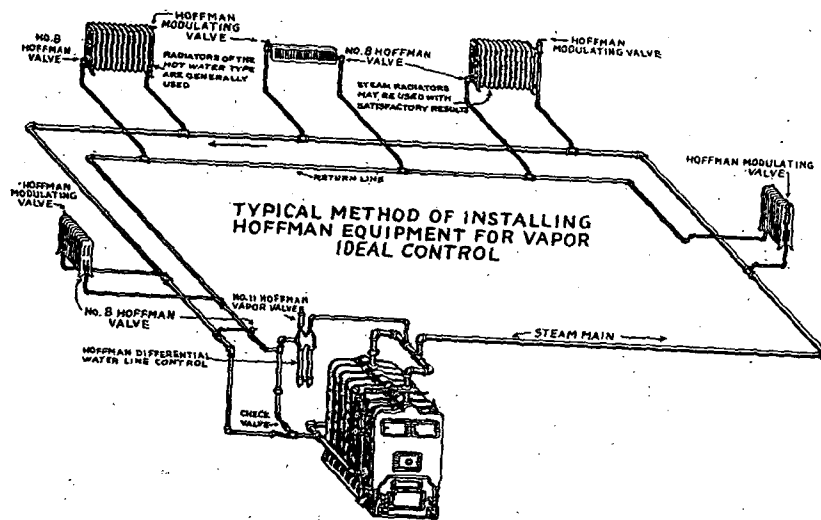
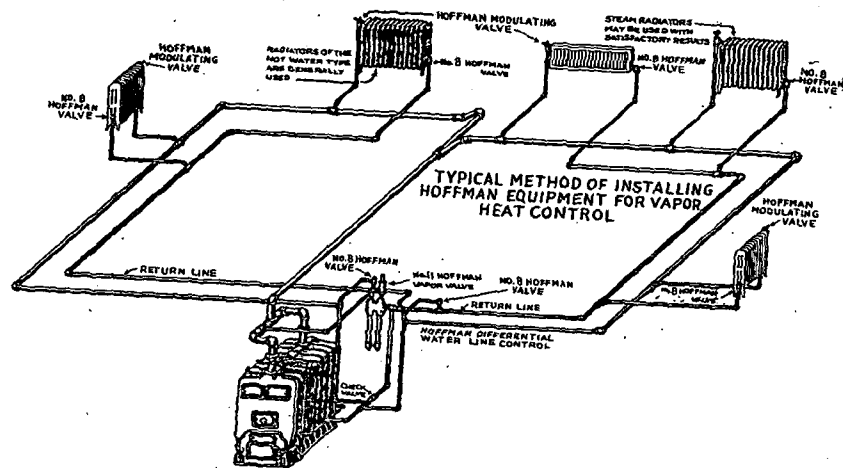


Fig. 4



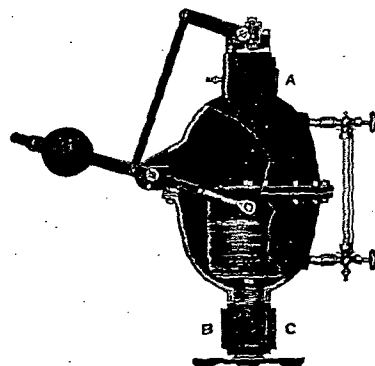
Kieley & Mueller Co., Inc.

34-38 West 13th Street

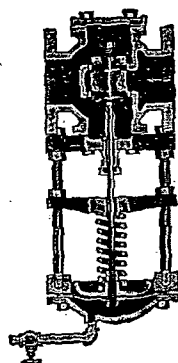
New York City

Agents in all principal cities.

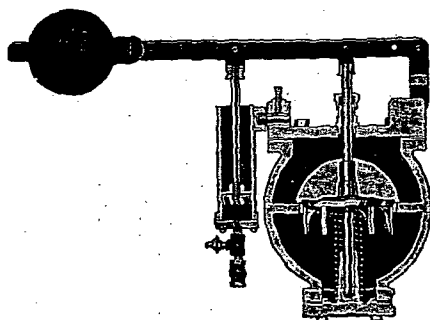
Manufacturers of Steam Specialties



Pump Governor



Reducing Valve



Back Pressure Valve

The illustrated specialties make a complete economy outfit, reducing steam from High to Low pressure; utilizing the exhaust and returning all condensation back to boilers automatically.

In addition thereto, we carry a complete line of various Reducing Valves for Steam, Water and Air. Tank Controllers High and Low Pressure Damper Regulators, Return and non-return traps for all pressures. Back Pressure Valves for Condensing and non-condensing Engines. Float and Pump Governor Valves. Controlling devices for Liquid Ammonia

and Brine. Our No. 27 catalogue and information on your difficult problems, furnished on request.

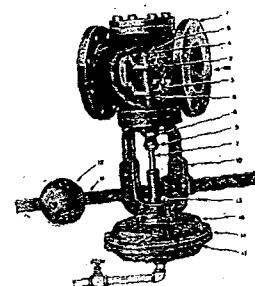
THE McALEAR MFG. CO.

1901-1907 So. Western Avenue

Chicago

Power and Heating Specialties for Controlling Pressures and Flow of Steam, Water, Air or Gas

Pressure Reducing Valves



McAlcar Vacuum-Vapor Pressure Regulating Valve, Full Area

Fig. Nos. 165-175

Size	Face Dim.	Center to Btm.	Top
3/4	3 1/2	15	1 3/4
1	4	15	1 3/4
1 1/4	4	15	1 3/4
1 1/2	4 3/8	15	1 3/4
2	5	17	2
2 1/2	8	18 3/8	5
3	9 3/4	19	5 1/4
3 1/2	10 3/8	20	6 1/4
4	12	20	6 1/2
5	12 1/2	20 3/4	7
6	13	21	7 1/2
7	14 1/4	21 3/8	8
8	16	22 1/4	8 1/4
10	18 3/4	24 1/4	10 1/4
12	21 1/2	29 3/4	10 1/2

Fig. Nos. 155

Size	Face Dim.	Center to Btm.	Top
1x2	5	17	2
1 1/4x2	5	17	2
1 1/2x2	5	17	2
1 1/2x3	7 1/2	18	4 1/2
2x4	8 1/4	18 1/4	4 3/4
2 1/2x5	9 3/8	19 1/2	5
3x6	10 1/2	19 1/4	5 1/4
4x6	11 1/2	20	6
4x8	10 7/8	20	7
5x8	12 1/4	20 1/2	7
5x10	12 3/8	22 1/2	8 1/2
6x8	14 3/8	21	8
6x10	14 3/8	22 1/2	8 1/2
6x12	14 3/4	22 3/4	10 1/2
8x12	16 1/4	23	11

Valves in standard pattern suitable for initial pressure up to 125 lbs. and reducing to service pressure 0-10 lbs. Valves for service pressure above 10 lbs. specify Fig. Nos. 235-245.

Specify Fig. Nos. 255-265 Single Seated Valves on dead end service such as cooking tables, kitchen utensils, laundry mangles, etc. Specify Fig. Nos. 185-195 Single Seated Valves on dead end service where reduced pressure is below 10 lbs.

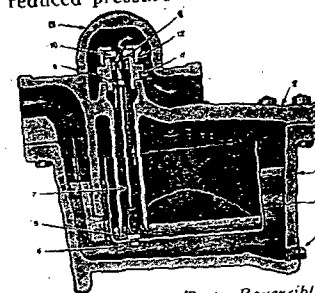
Size	Capacity Lbs. Water Per Hr.	Capacity Sq. Ft. Radiation	Distance Center of Inlet and Outlet to Bottom
1/2	450	1,500	8 3/4
3/4	660	2,200	9
1	1,050	3,500	10 1/2
1 1/4	1,650	5,500	10 1/2
1 1/2	3,600	12,000	11 1/2
2	5,100	17,000	12 1/2
2 1/2	6,250	22,500	12 1/2
3	7,650	25,500	19 5/8

Specify Fig. 685 for pressures up to 30 pounds.

Fig. 695 for pressures from 30 to 125 pounds.

Fig. 705 for pressures above 150 pounds.

Fig. 715 for special low pressure.



McAlcar Steam Trap, Reversible Seat

Ask for literature.

Bulletin A—Two Pipe Vacuum Heating System.

Bulletin B—Vapor Heating System.

Bulletin C—Air Line Vacuum Heating System.

Bulletin D—Packless Radiator Valves.

Bulletin E—High and Low Pressure Steam Traps.

Catalog 25—Heating, Power and Plumbing Specialties.

Our new 128-page catalog gladly furnished upon request.

Monash-Younger Co.

Chicago



New York

Thermostatic Return Line Traps, Adjustable and Non-Adjustable Automatic Air Valves for Radiators, Packless Radiator Supply Valves

Monash Ten Year Guaranteed Return Line Traps



The distinctive feature of the Monash Thermostatic Trap is the Diaphragm, a separate and independent unit, so held in place that it minimizes the possibility of fracture or rupture. The No. 35 Trap here illustrated is made with the expanding element on either side of the seat. This is the same diaphragm that has been in use in the Continental and Commercial National Bank, Chicago, since the fall of 1914 and not one of these thirty-three hundred diaphragms has been removed for any cause whatsoever, so that the upkeep cost has been nil, and the performance efficiency one hundred per cent. This record speaks for itself.

Monash Thermo Return Line Traps Made With By-pass and Clean-out Feature. Guaranteed For Ten Years On Pressures Up To 25 Pounds. For Mains, Risers, Drips, Blast Coils and in Industrial Plants. Many Thousands in Use the Past Fifteen Years.



No.	Size	Sq. Ft. Radiation	Lbs. Water Per Hr.
40	1/2 in.	350	108
42	3/4 in.	1500	475
44	1 in.	5000	1560

Monash No. 6 Four-Way-Drain Adjustable Lock-Shield, Self-Cleaning Automatic Steam Air Valve



has given excellent results for more than twenty years. Guaranteed for ten years in writing. The Four-Way-Drain clears the valve of all sediment and water of condensation by capillary attraction preventing flooding of floors and other damage. *How to Specify*—To each radiator attach a Monash No. 6 Four-Way-Drain, Lock-shield, Self-Cleaning, Automatic Air Valve, guaranteed in writing for ten years, and on Mains and Risers, use Monash Thermo No. 27 Quick Venting Valve."

Monash Non-Adjustable No. 1 Automatic Air Valve



with removable syphon, permitting the valve to be cleaned and the syphon replaced. Sensitive and quick in action, made of heavy metal with base and nipple cast in one piece and the body of the heavy shell screwed into the base. Guaranteed in the hands of the users for five years.

O-E Specialty Mfg. Co.

880 Third Street

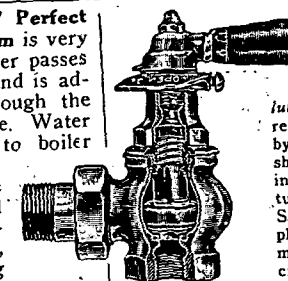
Milwaukee, Wis.

Packless Graduated Valves, Ball-Check Return Elbows, Thermo-Nickel Return Traps, Air Exhausters, Vacuum Valves, Vacuum Pressure Gages, Differential Return Traps.

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 1/2-inch "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. 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.



The "O-E" Perfect Ball-Check Water Seal Union Elbow with Adjustable Air Vent is made in one size only, 1/2", each \$3.00. Capacity 250 square feet.



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 discs on a swivel seat without extra charge. Graduation Supply Disc will be attached when specified, at slight additional cost.

Standard Sizes

Size	List, Each
1/2"	\$4.25
3/4"	5.00
1"	6.00
1 1/4"	7.50



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 Carbon Post 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-inch I. P. both inlet and outlet. Made in one size only, 1 inch, each \$10.00. Capacity 2500 square feet.

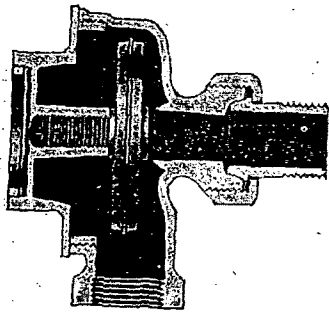
We also announce the Thermo-Nickel Return Trap, a combination thermostatic trap with a ball-check and many new features. Ask for descriptive bulletin.

Sterling Engineering Co.

419 Third Street

Milwaukee, Wis.

Thermostatic Traps, Packless Valves, Return Traps



Sterling Thermostatic Trap

The Sterling Thermostatic Radiator Trap is designed for use on both vacuum and vapor heating systems. It is an all brass trap constructed with a vertical diaphragm with a flat seat. The expansion of the diaphragm closes the trap against the steam pressure. The vertical seat is a self-cleaning feature as dirt and scale after passing the seat drop down into the return line instead of collecting inside the trap. The diaphragm is the result of long and careful experiments. The metal is carefully tested before being used and the greatest care is exercised by skilled mechanics to insure perfection in each diaphragm. They are guaranteed to function properly for a period of at least five years.

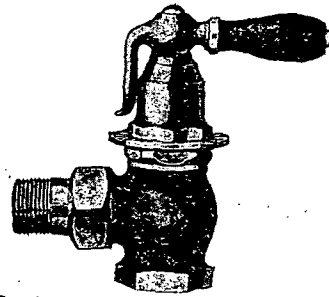
Capacities and Sizes

No.	Size	Capacity
1	1/2"	Up to 100 sq. ft. rad.
2	3/4"	100 to 200 sq. ft. rad.
3	1"	200 to 500 sq. ft. rad.
4	1 1/2"	500 to 1000 sq. ft. rad.

Sterlco Slide Valve Return Trap

The Sterlco Slide Valve Return Trap differs in principle from other return traps on the market by utilizing the sliding type of valve and besides draining return lines of heating systems and returning water to boilers, it will lift liquids to higher levels where steam or air pressure is available.

Size Return Traps	Sq. Ft. Surface	Inlet and Outlet	Steam Connect.	Vent Connect.	Height	Length Overall	Shipping Weight	List Price
1	2000	1 1/2"	3/4"	1/4"	14"	20 1/2"	150	\$100.00
2	4000	2"	3/4"	1/4"	16"	26"	190	125.00
3	7000	2"	3/4"	1/4"	18"	32"	250	150.00

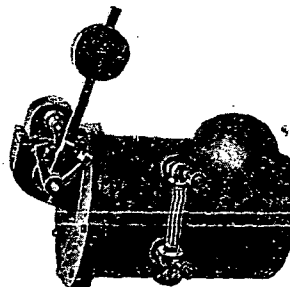


Sterling Graduated Packless Valve

The Sterling Graduated Packless Radiator Valve is of the Jenkins Disc Type. A half turn of the handle will open or close it. A graduated dial indicates the degree of opening through the valve. The valve is neat in appearance, easily dismantled as all parts are threaded and screwed together and does not require packing. These valves are furnished with either lever or wooden wheel handles or with lock and shield.

Capacities and Sizes

No.	Size	Capacity
A	3/4 x 1/2	Up to 40 sq. ft. rad.
B	1 x 3/4	40 to 100 sq. ft. rad.
C	1 1/4 x 1	100 to 150 sq. ft. rad.
D	1 1/2 x 1 1/4	150 to 200 sq. ft. rad.
E	1 3/4 x 1 1/4	200 to 250 sq. ft. rad.
F	2 x 3/4	Up to 40 sq. ft. rad.
G	1 x 1	40 to 100 sq. ft. rad.



Thermograde Valve Company

General Office and Factory:

Watertown, Mass.

Branch Offices in all Principal Cities

Steam Heating Systems, Hot Water and Automatic Steam Specialties

PRODUCTS:

Thermostatic Traps
Float Return Traps
Modulation Valves
Full Opening Valves
Hot Water Valves
Dirt Strainers
Automatic Electric Pump and Receiver
High Pressure Steam Traps
Automatic Boiler Return Trap
Automatic Air Vent Trap
Blast Traps

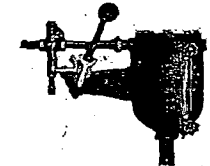
The Thermograde Modulation system of heating is a two pipe system adapted for use in connection with either live or exhaust steam where the water of condensation is returned to the boiler mechanically, or by gravity. It is adapted for use in all classes of buildings, high grade residences, apartment buildings, schools, hospitals, office buildings, factories, in fact any building where heat is desired.

The Modulation Valve has no stuffing boxes to leak, does not require repacking from time to time and with its self-indicating dial, hand regulation can easily be maintained.

The new improved Auto Valve is factory adjusted but is so constructed that adjustments can be made at installation if necessary due to unusual conditions existing. This valve is made entirely of bronze, highly nickel plated. It has a hand spun phosphor bronze diaphragm, no springs, entirely automatic, noise-

less in operation and self cleaning. It will not pass steam but will relieve air and condensation from the units of radiation, maintaining their efficiency at all periods.

The Special Return Trap operates automatically, returning the water of condensation to the boiler at all times regardless of the pressure on the boiler, keeping the system free from air and preventing the loss of steam.



The Belvac Thermofier is a float operated trap and is used mainly on vacuum systems. It passes no steam but the air and water are released as fast as they accumulate in the units. The trap is never closed against their free passage, they are positively and immediately removed.



The Modulated Hot Water Valve has a self-indicating dial and can be adjusted to regulate the flow to the various units—this means hand temperature regulation for gravity or forced circulation hot water heating systems.

Our interest does not lie merely in selling a number of valves and traps—we aim at real service. Each and every installation must be an asset, and in our twenty years of experience we have made thousands of satisfied users.

Send for literature.

The Trane Company

La Crosse, Wis.

Chicago, New York, Boston, Cleveland, Buffalo, Salt Lake City, Philadelphia, Detroit, Washington, D. C., Portland, Ore., Seattle

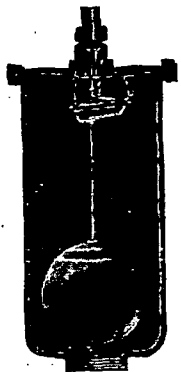
The Trane System of Vapor Heating, Patented Heating Specialties
Trane Automatic Electric Pumps, For All Purposes

Trane Direct Return Trap

For returning the water of condensation of any heating system to the boiler during periods when pressure difference between boiler and return pipe is such as to prevent the returning of the condensation by gravity. This efficient device allows steam to enter the trap whenever the trap body becomes filled with water, thereby equalizing the pressure and allowing the water to return to the boiler by gravity.

The Trane Direct Return Trap mechanism is all inside the case, as shown in the accompanying cut. Because of its simple, efficient construction this trap requires no attention after being installed. Note that it has no stuffing boxes, outside joints, or weights.

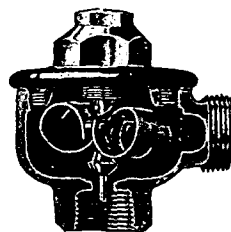
Complete detailed drawings for installing are furnished with each trap.



Trane Direct Return Trap in Section. Note that this trap has no stuffing boxes, outside joints, or weights.

Trane Thermetal Radiator Trap

The distinctive feature of this trap is that it has no diaphragm. In all other respects, there is no radical departure in its entire construction from the best accepted principles of radiator trap construction. Eliminating the diaphragm



Semi-sectional view of trap, showing Thermetal member in position. This trap has a safety factor of fourteen.

eliminates all source of trouble. This trap is fully as sensitive as the delicate diaphragm type of trap, yet so rugged that it is not injured by high pressure.

The thermostatic member in the Trane Trap is made entirely of metal. No liquids are used, and nothing can happen to render its force inoperative.

Use it on all two-pipe vapor or vacuum systems, in residences, apartments, hotels, factories, warehouses, garages, schools, churches, hospitals, offices, etc. Trane Thermetal Traps meet the highest engineering standards as well as the practical need for an absolutely dependable and permanent radiator trap.

Bulletins on other specialties, on The Trane System of Vapor Heating, and on Trane Pumps are obtainable for the asking.

Warren Webster & Company

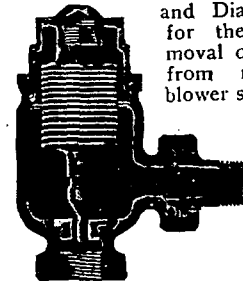
Camden, N. J.

Branches in All Principal Cities

Heating Systems, Heating and Power Specialties

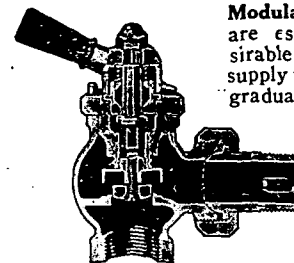
The Webster Heating Specialties include:

Radiator Traps—Sylphon Bellows and Diaphragm types—for the automatic removal of air and water from radiators, coils, blower sections and other forms of apparatus emitting heat due to condensation of low pressure steam.



Heavy-duty Traps for discharging unusually large volumes of air and water from low-pressure radiating units. This is a float trap with a built-in thermostatic trap in the air-pass. For steam pressures ranging from 15 to 50 lb. per sq. in. a similar trap is known as the Webster High Differential Heavy-duty Trap.

Double-Service Valves for accomplishing the two-fold purpose of draining down-feed risers and supplying steam to radiators at adjacent points.



Modulation Valves are especially desirable as radiator supply valves where graduated or modulated heating as well as quick heating are the objectives.

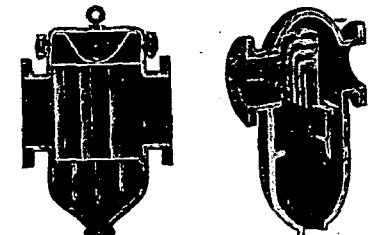
Quick-opening Radiator Valves are of the highest quality of construction and are similar to Modulation Valves without the graduation feature.

High-pressure Sylphon Traps are used for draining sterilizers, kitchen equipment or other apparatus using steam at pressures up to 100 lb. per sq. in.

Modulation Vent Traps are used in Modulation and other Open Return Heating Systems for ensuring the automatic removal of air from the return and the discharge of the condensation to the boiler, when the pressure difference between the boiler and the main return is normally less than the available gravity head between the return main and the boiler.

Where the design of the system requires a continuous operating steam pressure varying from two or three pounds to occasionally ten pounds, or where special grades of fuel make it difficult at times to maintain a low steam pressure, even with careful firing, the Webster High-duty Vent Trap is installed. This trap alternately frees the system of air and returns the condensate to the boiler regardless of the pressure in the boiler or in the return piping.

Miscellaneous Specialties for Webster



Heating Systems include Oil Separators, Grease and Oil Traps, Dirt Strainers, Suction Strainers, Lift Fittings, Vacuum Governors, Air-Separating Tanks, Hydro-pneumatic Tanks, Vacuum Controllers, Conserving Valves, Low-pressure Boiler Feeders, Damper Regulators, Water Accumulators, Expansion Joints, Vapor Economizers, etc.

Webster Power Specialties include Feed Water Heaters, Heater Meters, Steam Separators, etc.

See our Service Bulletins or Data Books for complete description of apparatus, and its application to Webster Systems.

The Automatic Furnace Co.

Dayton, Ohio

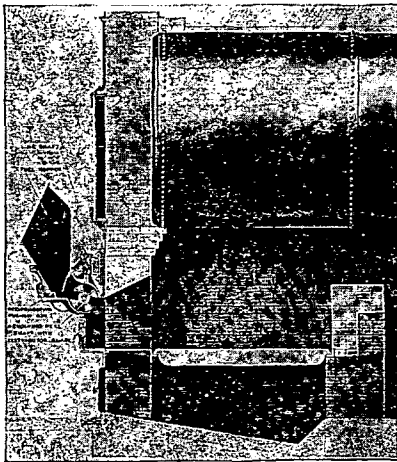
Branch Offices

NEW YORK, N. Y.
PITTSBURGH, PA.

CHICAGO, ILL.
ATLANTA, GA.

ST. PAUL, MINN.
DETROIT, MICH.

Manufacturers of Smokeless Furnaces, Chain and Shaking Grates



Showing Dayton Coal Feeder Applied to Horizontal Fire Tube Boiler

PRODUCTS

Model Automatic Smokeless Furnaces; Model Chicago Chain Grate; Dayton Coal Feeder; Culver Shaking and Dumping Grate; Model Acme Steam Engine.

THE DAYTON COAL FEEDER automatically feeds the coal onto any grate. It gives an even distribution of fuel over the entire grate surface and the fuel saving never amounts to less than 15%.

Burns the lower grades of fuel that usually go to waste at the mines.

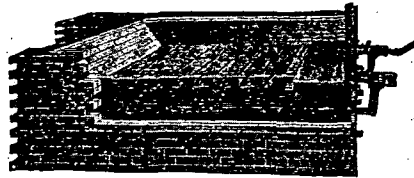
The saving in fuel will repay the installation cost in a short time. It is simple in design and practically fool-proof. It reduces the amount of labor required.

Practically no maintenance cost.

It is easily and quickly installed without change in the boiler setting at comparatively small cost.

CULVER SHAKING AND DUMPING GRATE has both a shaking

motion, which is sufficient to clean the grate surface of ash and clinker, and a



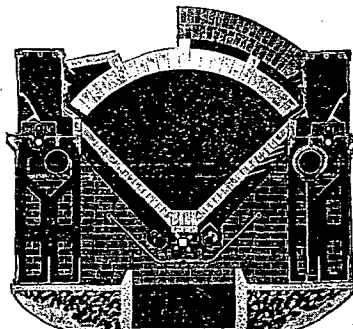
Culver Shaking and Dumping Grate

dumping motion in which every other grate raises up and the others drop down. When in this position the grates can be rocked, which breaks up the largest and hardest of clinker, and as an 8-inch opening is afforded everything on the grates is dumped into the ash pit.

THE MODEL AUTOMATIC SMOKELESS FURNACE is of the well-known side feed inclined grate type and is suitable for the larger heavy duty units. It is entirely automatic, cleaning the ash and clinker from the fire as well as feeding the fuel to the fire. Heavy overloads can be carried due to the fact that the fire is always clean and as the cleaning mechanism will handle the dirtiest of coal the refuse from the mines can be burned instead of wasted.

The design is simple, strong and durable and no parts, except the grate bars, are exposed to the heat of the fire.

Shown below.



This Company also manufactures the **MODEL CHICAGO CHAIN GRATE**. It is of rugged, heavy construction and is designed to stand the trying service of boiler room equipment. Detailed description will gladly be sent on request.

Murphy Iron Works

Founded 1878

Detroit, Michigan

Branch Offices:

Boston, Worcester, New York, Philadelphia, Pittsburgh, Buffalo, Cleveland, Cincinnati, Chicago, St. Paul, Denver.

General

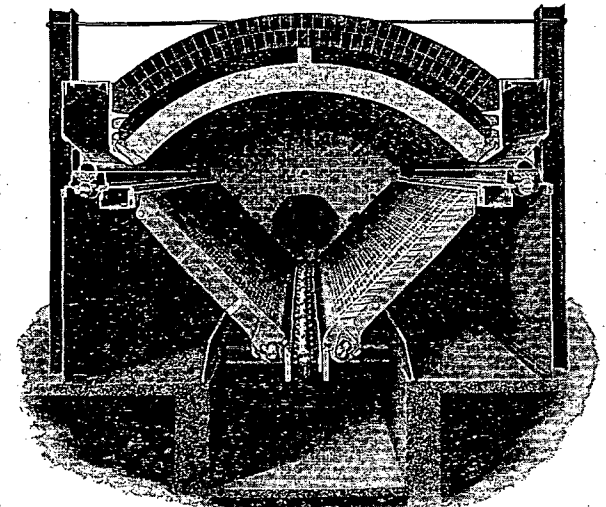
The Murphy Automatic Furnace is particularly adapted for use in office buildings, hotels and schools. It saves 15 to 25% of coal over hand-fired methods—it eliminates the smoke problem. The labor saving depends on the number of men employed. Where only one man is employed there is, of course, no saving, but he can devote more of his time to other duties.

Description

The correctness of the principle upon which the construction of the **MURPHY AUTOMATIC FURNACE** is based has been demonstrated by 44 years of stoker experience. Improvements have been made from time to time which have increased its efficiency and durability. With the **MURPHY AUTOMATIC FURNACE**, complete combustion prevents smoke and ensures high CO₂ results. 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 for opening furnace doors and thereby eliminates the admission of cold air; the coal supply to the furnace is under absolute control and automatic regulation; it is a Natural Draft Furnace and requires no expensive fan or blower equipment.

Adaptability

The Murphy Furnace is designed for any type of boiler in units from 50 h.p. up. It is exceedingly flexible and efficiently handles variable loads and overloads up to 200% of boiler rating with minimum attention and without forced draft.



Maintenance

Maintenance cost is low; averaging about 10 cents per B.H.P. per year. The magazines and fronts are protected by fire brick; the coking plates by air passing under them; and the clinker grinder, grate bearer and grates by exhaust steam and air, thus ensuring ample protection to all working parts.

Installations

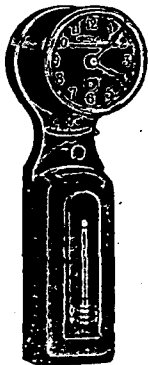
A few of the many Murphy installations in office buildings, hotels and schools.

Hamm Building, St. Paul, Minn.
Cleveland Discount Bldg., Cleveland, O.
State Office Building, Lansing, Mich.
Parliament Buildings, Ottawa, Canada.
Edison Building, Chicago, Ill.
Lafayette Hotel, Buffalo, N. Y.
Blackstone Hotel, Chicago, Ill.
Union Bank Bldg., Pittsburgh, Pa.
Congress Hotel, Chicago, Ill.
Statler Hotels, Cleveland, O., Detroit, Mich., and Buffalo, N. Y.
University of Michigan, Ann Harbor, Mich.
76 School buildings in Detroit.
33 Schools in Cleveland.

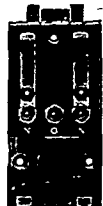
Honeywell Heating Specialties Company

Wabash, Indiana

Manufacturers of Honeywell and Arco Temperature Regulators for Residential or other Heating Plants—Hot Water, Vapor, Steam, or Hot Air.



Model 8 Automatic Thermostat



Wall Plate Used on all Honeywell Thermostats

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 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 eight-day automatic thermostat which automatically regulates both the day and night temperatures, at any predetermined degree and hour, without manual adjustment of any kind.

PRICES

Including all wire, chain, pulleys,

brackets, etc., necessary for installation. These prices are subject to trade discounts.

Gravity Motor Models

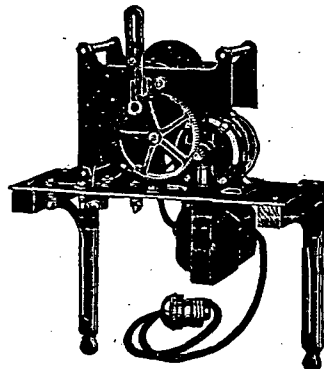
Model G-4, Plain non-automatic night-to-day temperature regulation.....	\$38.00
Model G-6, One-day clock pattern thermostat, automatic night-to-day temperature regulation.....	45.00
Model G-8, Eight-day automatic thermostat, automatic night-to-day and day-to-night temperature regulation.....	58.00

Spring Motor Models

Model 4, Plain non-automatic night-to-day temperature regulation.....	\$45.00
Model 6, One-day clock pattern thermostat, automatic night-to-day temperature regulation.....	52.00
Model 8, Eight-day automatic thermostat, automatic night-to-day and day-to-night temperature regulation.....	65.00

Electric Motor Models

Model 14, Plain non-automatic night-to-day temperature regulation.....	\$70.00
Model 16, One-day clock pattern thermostat, automatic night-to-day temperature regulation.....	77.00
Model 18, Eight-day automatic thermostat, automatic night-to-day and day-to-night temperature regulation.....	90.00



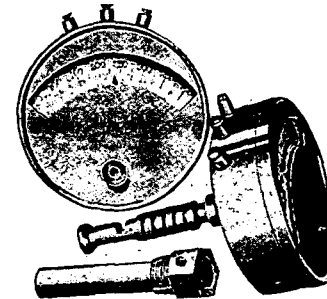
A. C. Electric Motor with Cover Removed

MINNEAPOLIS HEAT REGULATOR CO.

MAIN OFFICE
MINNEAPOLIS, MINN.

Service Branches in Principal Cities
Manufacturers of Temperature Controlling Devices

In addition to the standard line of Minneapolis Heat Regulators for use in residences for the control of the central heating systems, this Company manufactures the special devices shown below which have a wide range of uses in special work. Our engineering department is always at the service of the profession in working out special adaptations of these devices.



Model No. 65 Hot Water Thermostat

This Model is especially made for the control of domestic hot water supply in residences, apartments, hotels, etc. It can be used to control a coal heater in summer and steam valve in winter. It will give an accurate and dependable control. It is long-lived and fool-proof. Can be used with Minneapolis A. C. or spring motors.

Other Uses

Control of hot water boilers in residences in connection with room thermostat control.

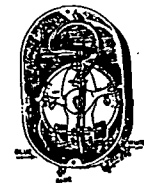
Enamelling and bake ovens, dry kilns, glue, oil, paraffin and chocolate vats. Refrigerating systems, etc.

Description

Size—Diameter, 4 inches; extension, 2 or 4 inches standard; scale 50 degrees to 400 degrees; extreme temperature, 0 to 500 degrees. Extensions can be furnished up to 24 inches with special scales to suit any requirements.

Model No. 70

Pressure Regulator



Cut 2 shows the construction of the Pressure Regulator. Simple, rugged and sturdy in construction. It can be set at any point at will to keep a given pressure, as for example 3 pounds, or to keep the pressure always within a certain range, as not less than 4 ounces nor over 1 pound.

The Pressure Regulator used in connection with a thermostat is the ideal installation in connection with house heating plants, whether steam or vapor. There are two independent sources of control working on the boiler, both temperature and pressure. For example, the thermostat in the room is set at 70 degrees and the pressure control at ½ pound. When the temperature reaches 70 degrees the dampers of the heating plant will be closed even though the pressure is only ½ ounce. And vice versa, in the morning or whenever the fire is being forced the pressure will be built up faster than the rooms are warmed, the pressure reaching ½ pound before the temperature reaches 70 degrees. Then the Pressure Regulator closes the dampers and the vapor or steam will continue to raise the temperature. This prevents the overheating that at times will occur when only the temperature control is used.

Pressure Regulators are not only applicable to heating plants, but also to any type of pressure control, compressed air tanks, etc. Standard range is 0 to 5 pounds, but special ranges for other pressures desired can be furnished at a slight additional cost.

THE POWERS REGULATOR CO.

Specialists in Automatic Heat 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:

BOSTON, MASS.
CINCINNATI, OHIO
DETROIT, MICH.
DES MOINES, IOWA
MINNEAPOLIS, MINN.
EL PASO, TEXAS
CLEVELAND, OHIO
BUFFALO, N. Y.

ROCHESTER, N. Y.
SAN FRANCISCO, CAL.
ST. LOUIS, MO.
PITTSBURGH, PA.
SEATTLE, WASH.
KANSAS CITY, MO.
SALT LAKE CITY, UTAH
INDIANAPOLIS, IND.

CHARLOTTE, N. C.
LOS ANGELES, CAL.
BUTTE, MONT.
MILWAUKEE, WIS.
PORTLAND, ORE.
BALTIMORE, MD.
PHILADELPHIA, PA.

THE CANADIAN POWERS REGULATOR CO., LTD., TORONTO, ONT.

BRANCHES:
MONTREAL, WINNIPEG, CALGARY, VANCOUVER

Products and Services

Automatic Temperature Controlling Systems, applying them, under the supervision of the Powers engineers, to the heating plants, new or old, in residences, offices, factories, schools, institutions, and to any other condition of artificial heating where uniform temperature is desired. Automatic Heat Regulating Devices for controlling hot water and other tank heaters, hot water lines, shower baths, mixing hot and cold water, cold water and steam, and other operations of a similar character.

Heating systems, and the requirements for temperature control, vary widely in detail. Special study should be given each case, so that its particular requirements may be intelligently handled. Much of the dissatisfaction experienced with some temperature regulating apparatus 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.

Temperature Controlling Appliances

Powers thermostats are accurate in their working and will maintain their adjustment. They are of the vapor disk type, exclusive with Powers regulators, and the only type not thrown out of adjustment by extremes of temperature or long disuse. For over 30 years this 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 nec-



Residence
Thermostat

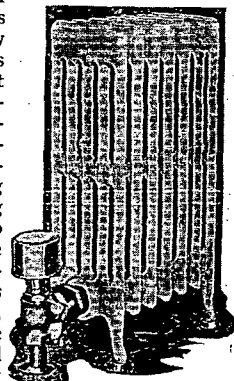
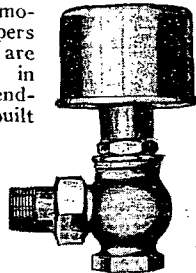
essary in such instruments; in operation, sure, with gradual or positive action, as conditions require.

Diaphragm radiator valves, diaphragm motors, mixing dampers and other equipment are especially rugged in construction, dependable, and durable; built regardless of expense, wherever strength is needed for efficiency and long service.

Motive power used in these systems is compressed All-Metal Radiator Valve air. The company builds its own air compressors, operated by steam, electricity or water, and characterized by their reliability, noiseless operation, perfect control and long life.

Installations

Installations of Powers systems are invariably made by this 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 plumber.



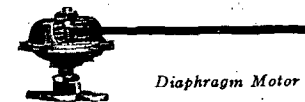
Valve Attached to Radiator

Prices

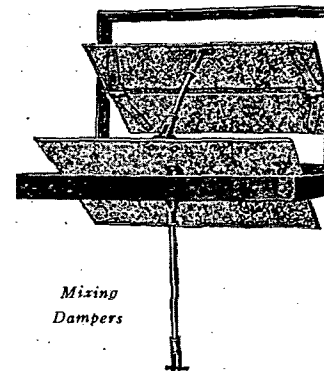
Price for Powers Regulation covers the system installed complete, and is only named after a careful study of the requirements. Our price is not lowest, but no other system will be found as efficient and economical. Customers are served with the sole aim of getting results for them; and experience shows that satisfactory service from a temperature controlling system is of much more importance than its first cost.



Heavy Duty
Thermostat



Diaphragm Motor



Mixing
Dampers

Specifications

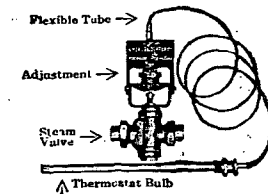
An opportunity is solicited to submit to any architect or engineer a detailed specification, accompanied by a guaranteed price, to cover complete system of temperature control installed, the price to hold if specification is used. This guarantees full protection to the client against advantage being 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 Co. has unusual facilities for solving problems in this particular field.

Tank Temperature Regulation

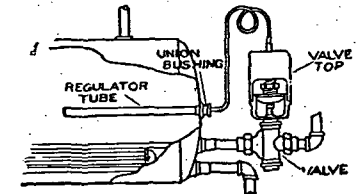
No. 11 Regulator controls temperature of liquids of all kinds under all condi-

tions. Self-contained, requiring no water or other auxiliary operating power. All-metal. Of great durability, guaranteed accurate and positive in action. Very easily installed. Largely used on hot water tanks and heaters, glue heaters, paraffin and grease tanks, etc.

No. 12 Regulator, same as No. 11, with lever instead of spring equipment. On request, it is furnished complete with chains and pulleys, for control of dampers of auxiliary coal burning tank heater, both heat sources being controlled with one regulator.



No. 11 Regulator



Typical Installation of No. 11 Regulator
in Hot Water Heater

For more detailed information on No. 11 or No. 12, ask for Bulletin No. 129.

Price List, No. 11 and No. 12 Regulators Complete with Valves

Size of valve, in.	Price	Size of valve, in.	Price
1/2	\$60.00	3	\$100.00
3/4	65.00	3 1/2	110.00
1	70.00	4	120.00
1 1/4	75.00	5	175.00
1 1/2	80.00	6	200.00
2	90.00	8	250.00
2 1/2	95.00		

Screwed union valves up to 1 1/2-in. inclusive. 2-in., 2 1/2-in. and 3-in., screwed iron body; larger sizes, iron body flanged. Flexible connecting tube is 6 ft. long for sizes 1 1/4 in. and smaller; 8 ft. for 2 to 4 in. inclusive; and 10 ft. for larger sizes. Extra charge for special lengths. Bulb lengths, 14 to 24 in. requiring 1-in. and 1 1/4-in. tapping.

Liberal discount to the trade.

Water Line Temperature Regulation

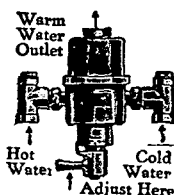
Shower Bath Controller

This device furnishes absolute thermostatic control of the water supply to shower baths, either singly or in gangs. Entirely automatic in operation, and thermostatically controlled against scalding. Will cut off hot water completely if cold water supply fails. Made in several sizes, to control from 1 shower to 50.

The larger sizes may be installed in the hot water line, to prevent extremely hot water from going to the bathroom, saving wear and tear on the fixtures, but permitting the kitchen and laundry to take it as hot as may be desired. Fur-

nished complete as illustrated, with unions, strainers, and check valves, ready to connect.

Regularly furnished with maximum temperature adjustment of 110 degrees Fahrenheit. Higher adjustment furnished when specified. Always state purpose for which controller will be used.



Shower Bath Controller

Smaller sizes, full nickel finish. Larger sizes, black enamel or aluminum finish.

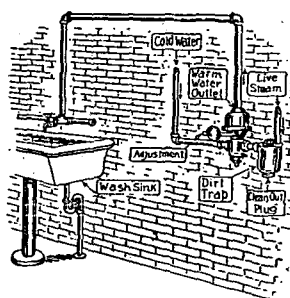
PRICE LIST, POWERS SHOWER BATH CONTROLLERS

No.	Description	Pipe Sizes		Capacity, gals. per min.	Price
		Inlet, in.	Outlet, in.		
1	Nickelplated brass body, screwed connections ...	3/4	3/4	Individual shower	\$100.00
3	Nickelplated brass body, screwed connections ...	1	1	25	125.00
4	Nickelplated brass body, screwed connections ...	1 1/4	1 1/4	50	150.00
5	Galvanized iron bodies, painted, flanged connections ...	1 1/4	1 1/4	80	175.00
6	Galvanized iron bodies, painted, flanged connections ...	1 1/2	2	100	185.00
7	Galvanized iron bodies, painted, flanged connections ...	2	2 1/2	150	200.00
8	Galvanized iron bodies, painted, flanged connections ...	2 1/2	2 1/2	200	225.00

Capacities are based on 40 lbs. water pressure. Liberal discount to the trade. For more detailed description ask for Bulletin No. 124.

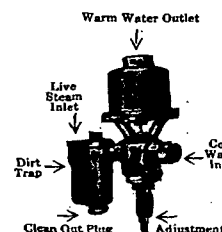
Thermostatic Water Heater

A safe, sure and accurate method of heating water with high pressure steam. Thermostatically controlled. Adapted to workmen's wash sinks, shower baths, etc., in factories, mines and other industrial plants, and to a great variety of purposes where a supply of warm or hot water of a specified temperature is desired at irregular intervals.



Typical Installation of Thermostatic Water Heater in Workmen's Wash Sinks

Thermostatic Water Heater



PRICE LIST, STEAM AND WATER MIXERS

No.	Pipe Sizes		Capacity, gals. per min.	Shipping weight, lbs.	Price
	Inlet, in.	Outlet, in.			
	Steam	Water			
1	1 1/4	3/4	25	60	\$100.00
2	1 1/2	1	40	75	150.00

Liberal discount to the trade. For more detailed information ask for Bulletin No. 137

The Heating Ventilating Magazine

A MONTHLY JOURNAL OF ENGINEERING PROGRESS

1123 Broadway, New York

THE HEATING AND VENTILATING MAGAZINE is devoted to the engineering progress of the industry and is conducted in the interests of consulting, heating and ventilating engineers, contractors, central station heating engineers, engineers, of school boards, architects, manufacturers, etc. The subscription price is \$2.00 per year.

Following are the partial contents of a typical issue:

The Weak Spots in Direct-Indirect Heating, E. Vernon Hill (Significant Results of a Test of Air Conditions in the Greentown, Ind., High School).

Novel Scheme for Regulating the Humidity in an Airplane Propeller Factory, A. C. Knauss (Details of the Air Conditioning Apparatus Developed at the U. S. Forest Products Laboratory, Madison, Wis.).

What About Ozone? III. E. Vernon Hill and John T. Aeberly, (Details of the Recently-Completed Tests to Determine the Status of Ozone).

Standard Specifications for Chimney Construction (Text of the Model Ordinance Promulgated by the National Board of Fire Underwriters and Approved by Eleven Engineering and Trade Associations).

New Rulings for Public School Ventilation in Pennsylvania.

Legal Decisions.

Research Department.

Steam Required to Operate Sterilizing and Cooking Apparatus.

Checking Readings of Condensation Meters.

Velocities and Friction Losses in Ventilating Ducts.

Steam Required in a Blower Line in a Railroad Roundhouse.

Correspondence.

Chats with Uncle Ben (Cooling Water with Chemicals).

The Weather for November, 1921.

Through its membership in the Associated Business Papers, Inc., THE HEATING AND VENTILATING MAGAZINE has subscribed to the following Standards of Practice for Business Papers, as established by that body:

The publisher of a business paper should dedicate his best efforts to the cause of business and social service, and to this end should pledge himself:

1. To consider first the interests of the subscriber.

2. To subscribe to and work for truth and honesty in all departments.

3. To eliminate, so far as possible, his personal opinions from his news columns, but to be a leader of thought in his editorial columns and to make his criticisms constructive.

4. To refuse to publish puffs, free reading notices, or paid write-ups; to keep his reading columns independent of advertising considerations, and to measure all news by this standard: "Is it real news?"

5. To decline any advertisement which has a tendency to mislead or which does not conform to business integrity.

6. To solicit subscriptions and advertising solely on the merits of the publication.

Through its membership in the Audit Bureau of Circulations, the circulation of THE HEATING AND VENTILATING MAGAZINE is guaranteed, both as to the number of paid subscribers and to the proportion of subscribers in each branch of the industry.

This journal is also the publisher of The Heating and Ventilating Magazine Standard Data Sheets, now numbering over 222 sheets, covering a wide range of subjects connected with heating and ventilation. These sheets are sold at 5 cents each, or by the set, according to subjects.

The Dole Valve Company

1923-1933 Carroll Avenue

Chicago, Ill.

Manufacturers of a Complete Line of High Grade Packless Radiator Valves and Automatic Air Valves

Packless Radiator Valves

Dole Packless Radiator Valves are made in a large variety of suitable patterns to meet all requirements of any kind of Steam or Hot Water Heating System. All patterns embody same construction, the design only being changed to conform to the required pattern.

Wood knob handle, finely finished; no metal to come into contact with hand.

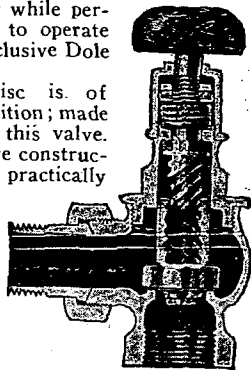
Stem in one piece; shoulder under packless disc is part of stem, and shoulder above disc is part of bonnet. Stem does not rise or lower; seat disc holder only rising and lowering on double spiral thread when stem rotates, its free working permitting coming to a positive seat when closed. This feature also prevents grease and dirt being carried through.

Spring is case tempered and carries tension of 75 to 100 pounds when compressed in valve. Spring rests on top of bonnet shoulder, held in place by lock nut on top of ball bearing feature. This continually pulls seat on stem against packless disc, which, together with small seating lip on upper and lower shoulders that imbeds itself in packless disc, insures tightness, preventing leakage of air, steam or water. Spring casing of high grade brass finely machined.

Ball bearing feature, consisting of iron steel balls set between specially hardened bronze, allows high tension in spring while permitting valve to operate freely—an exclusive Dole feature.

Packless disc is of special composition; made expressly for this valve. Owing to valve construction there is practically no wear on disc, as is proved by discs which have been in operation for 16 years with no apparent wear or deterioration.

Dole Angle Valve With Union
All Patterns of Dole Packless Valves Are
Constructed on this Basic Principle.



Discs are specially made according to different formulas for steam or hot water so that it is necessary to specify type of system when ordering.

Bonnet is extra heavy metal with very strong hexagon, allowing plenty of metal where wrench is used.

General construction comprises highest grade brass and bronze metals. Every valve seated and tested on 80 to 90 pounds steam pressure. Roughing-in dimensions as nearly standard as compatible with present variations of different manufacturers. Packless disc, spring and ball bearing features are standard on all patterns and interchangeable.

Right and Left Hand Corner Valve With Union

1/2"	\$3.45	1 1/4"	\$6.95
3/4"	4.25	1 1/2"	8.95
1"	5.15	2"	14.25

Graduated or Modulating Valve With Union

1/2"	\$4.15	1 1/4"	\$7.40
3/4"	4.80	1 1/2"	9.10
1"	5.75	2"	14.10

Wood Wheel Straight-Way Gate Valve With Union

1/2"	\$3.40	1 1/4"	\$6.75
3/4"	4.05	1 1/2"	8.25
1"	5.30	2"	11.90

Angle Valve With Union

1/2"	\$3.15	1 1/4"	\$6.25
3/4"	3.90	1 1/2"	8.15
1"	4.70	2"	13.00

Globe Valve With Union

1/2"	\$3.15	1 1/4"	\$6.25
3/4"	3.90	1 1/2"	8.15
1"	4.70	2"	13.00

Wood Wheel Gate Valve With Union

3/4"	\$4.45	1 1/4"	\$7.40
1"	5.80	1 1/2"	9.00
2"			\$13.00

Lock Shield Valve With Union

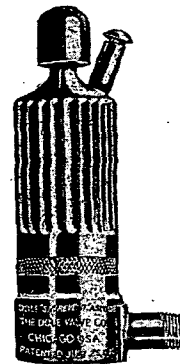
Same list as Wood Wheel Valves, but add 5% to net prices. Keys, 30 cents each, net.

Graduated Lock Shield Valve With Union

1/2"	\$4.15	1 1/4"	\$7.40
3/4"	4.80	1 1/2"	9.10
1"	5.75	2"	14.10

Keys, 30c each, net.

The Dole Valve Company



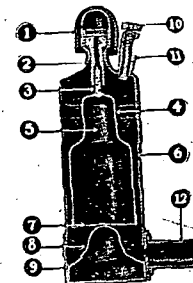
Shure-Vent Air Valves
List Price, Each
\$2.00

The Dole Shure-Vent Air Valve is an efficient automatic air valve in which has been overcome the possibility of interrupted action through accumulation of dirt, rust and corrosion, or the occasional annoying stoppage known as water-logging.

Float contains a specified amount of what is commonly known as expansion liquid. When air is expelled and steam approaches the heat vaporizes liquid. This expansion presses down diaphragm in bottom of float and closes valve. Water flooding into valve raises the float and also closes valve. The cooling of liquid reduces pressure on diaphragm and opens valve. Similarly, the draining of water also opens valve. This thermostatic and mechanical action is simple, positive and thoroughly automatic.

Water-logging, caused by a vacuum at top of valve holding water in valve, is overcome by the Dole emergency push button. Pressing down this button, and releasing immediately, will break the vacuum and drain the water. No removal or adjustment of valve or parts necessary.

Every valve properly sealed, adjusted and tested before leaving factory and each valve is guaranteed for the life of the heating system.



Sectional View

The Twelve Superior Features of Shure-Vent Air Valves

1—Double Cap arrangement which forces downward all air escaping from inner cap. This arrangement overcomes the reasons for the usual dust streak on wall above.

2—Seating Screw projects down into the chamber of valve far enough to form a guard which prevents dirt and flake working into the valve seat.

3—Seating Pin extends well up in the screw which forms a guide that insures a positive closing seat.

4—The Float made of light but strong annealed brass—rising when water enters the valve and positively prevents flood.

5—Inner Chamber of float contains exactly the proper amount of expansion liquid which expands and forms a gas the instant steam comes in contact with it—float rises and valve is closed tightly.

6—Finely Drawn Brass Shell, closely corrugated to form free passage of air and give natural drain for water.

7—Expansion Diaphragm is made of special spring bronze. Its convex shape permits the float to drop the exact distance necessary for free expulsion of air from the system while cold. The instant the air is expelled steam strikes the float. The heat then converts the liquid into a gas that expands this diaphragm forcing the pin at the top against the seat thus positively sealing the outlet against the escape of steam.

8—Float Rest of drawn brass, shaped and soldered into the base to form a perfect rest for the float yet giving free passage for draining water back into radiator—the bottom being aligned with inlet to the valve insuring complete drainage of the valve.

9—Heavy Drawn Brass Base threaded on the inside to which the outer shell is screwed and soldered. This arrangement makes a positive non-leakable connection of the utmost durability.

10—Push Button threaded and brazed to seat stem of the hand vent—impossible to remove or get out of adjustment.

11—The Hand Vent. Should water logging ever occur with a Dole Valve the owner or tenant merely pushes the button—and adjusts his own complaint, has abundant heat and is always satisfied. The vent seat is held firmly in place by a bronze spring of permanent tension precluding all possibility of leakage. This hand vent feature alone is sufficient reason for using the Dole Shure-Vent Valve.

12—Heavy Brass Nipple of Inlet securely brazed to the base and threaded with true cut standard one-eighth inch, iron pipe thread which conforms to the established standard tap on all makes of radiators.

The Fulton Company

Knoxville, Tennessee

NEW YORK
Hudson Terminal Bldg.
50 Church Street

BRANCHES:
DETROIT
Book Bldg.
Washington Boulevard

CHICAGO
Wrigley Bldg.
Michigan Boulevard

Representatives in All Principal Centers

Patentees and manufacturers of Sylphon products. Sylphon Temperature and Pressure Regulators, Thermostats for regulating temperatures of homes by warm air furnaces, steam or hot water boilers; Temperature Regulating Radiator Covers; Automatic Air and Vent Valves; Packless and Leakless Valves and other Heating Specialties

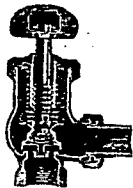
Advantages

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 1½" to 12" O. D.



No. 345 Sylphon Packless Radiator Valve

This valve cannot leak water, steam or air around the stem, and is known as our Government type. Turning stem and its support are completely surrounded by the 2-ply laminated Sylphon one-piece metal bellows, capable of being elongated as the stem descends and of being compressed as the stem rises. The operating parts are completely inside this protecting Sylphon bellows which forms a forever-tight seal between the main passage way and the stem opening. The valve is packless, not so-called, but absolutely packless. It is furnished with a non-burning handle of rosewood finish.



Ask for Bulletin RPV 3

No. 365 Sylphon Leakless Radiator Valve

It is absolutely tight against air, steam and water, and is just what its name implies—*leakless*. Contains no packing or springs, the stem rising through an opening that never requires packing, being enclosed within the valve body by the rugged, dependable 2-ply laminated Sylphon bellows which contracts or

expands as the stem is screwed up or down.

Sylphon Leakless and Packless Valves are especially adapted to vacuum

heating, steam and forced circulation hot water.

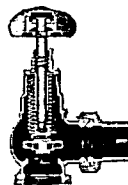
Non-burning handle of rosewood finish.

Furnished in angle, corner, globe, lock and shield, and other special types.

Ask for Bulletin RPV 3

No. 465 Standard Type Radiator Valve

A standard radiator valve of unusual quality as we use the same body, tail nut and tail pipe used in the Leakless Valve, which are of a superior quality to those generally made for standard valves.

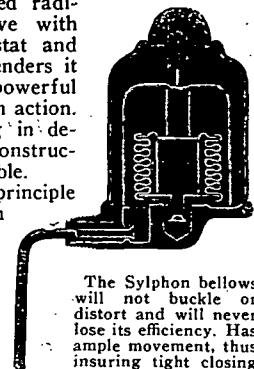


Ask for Bulletin RAV 3

No. 536 Sylphon Radiator Air Valve

An improved radiator air valve with large thermostat and float which renders it extremely powerful and positive in action. It is pleasing in design, rigid in construction and durable.

The active principle is the Sylphon bellows which for many years has been used by this company in all of its heating boiler specialties.



The Sylphon bellows will not buckle or distort and will never lose its efficiency. Has ample movement, thus insuring tight closing of the valve. It is so durable that, practically speaking, it will never wear out.

Ask for Bulletin RPV 3

The Fulton Company

No. 931 Temperature Regulator

For nearly all requirements where liquids are heated by steam, and especially industrial uses. Regulators are regularly furnished with a temperature range of 140 degrees to 180 degrees Fahr. Special regulators can be furnished with adjustment for 20 degrees above or below the operating point for temperatures not lower than 20 degrees nor higher than 320 degrees Fahr.

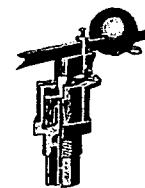
No. 931 Regulators are furnished regularly in sizes from ½" to 2½" inclusive.

Upon application, a chart will be furnished showing size of regulator

for any given condition.

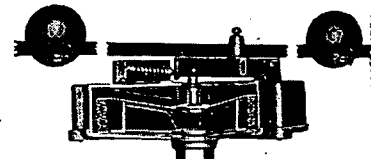
Ask for Bulletin RT 3

No. 45-A Water 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 degrees and 220 degrees Fahr. They prevent the temperature of the water from rising higher than necessary, insuring faucet water or even temperature every hour of the day. 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. 925 Vapor Damper Regulator

Extremely powerful and sensitive. It will control any pressures as low as 2 oz. and any dampers found on the average boiler. The extra flexible Sylphon diaphragm is 12 in. in diameter, giving 100 sq. in. effective area, and is fitted with a compensating device which overcomes

"Specification Data"

Send for our "Specifications of Value" which gives complete engineering data in regard to the above products.

friction in the moving parts and prevents the regulator from fluttering. The regulator is made entirely of metal and has no perishable rubber diaphragms.

Ask for Bulletin RD 3

Sylphon Regitherm

The most powerful room thermostat on the market. Requires no electricity, compressed air or clockwork to operate. Responds to slight changes in temperature of air and is used to control valves, dampers and shutters. Works smoothly, never by jerks and is noiseless in operation.



Requires no attention. Standard range 60 degrees to 80 degrees Fahr. It is largely used in offices and industrial plants. Small and neat in appearance, being 6" wide by 7½" long.

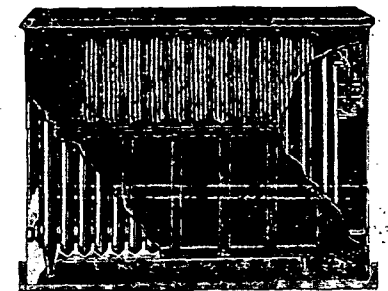
Ask for Bulletin RR 3

The Ja-Nar Radiator Cover

Made of fine furniture steel, lined with heat insulating material. Completely covers 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 any interior woodwork.

Furnished in three types: 1st, Automatic Temperature Control; 2nd, Manually Operated Temperature Control; 3d, Uncontrolled Type.

The controlled type Ja-Nar Radiator cover is equipped with a thermostatic device which opens or closes the shutters to regulate the heat sent out into the room. This is absolutely automatic in operation and can be set to operate at any comfortable temperature desired.



Ask for Pamphlet on the Ja-Nar

DETROIT LUBRICATOR COMPANY

DETROIT, U. S. A.

New York

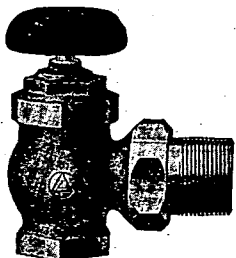
Chicago

San Francisco

Largest Manufacturers of Radiator Valves in the World

NEW OFFERINGS FOR 1922

Detroit Packless Radiator Valves Bellows Type



A more pleasing line of Packless Radiator Valves for steam, hot water, vapor and vacuum heating systems.

The Detroit Packless Radiator Valves, Bellows Type, have no rotating or sliding parts exposed to the steam or water. The operating parts are completely enclosed in a strong, elastic brass bellows which expands and contracts as the valve is opened and closed. Steam, water or air cannot pass through this metal barrier and leak through the stem opening. Conversely, no air can get into the system through the Radiator Valve, which is so necessary for a perfect and economical working vacuum system. The metal Bellows is of an improved type and will last as long as the heating plant itself.

A new and better design of handle is offered for the first time. It is a hard rubber finished, molded type which will not break or lose its finish and which is non-conductive of heat. It will not work loose on the stem.

The workmanship and finish of The Detroit Packless Radiator Valves, Bellows Type, are of the highest grade. They are of compact and pleasing appearance, and due to the absence of complicated and friction-producing mechanism, turn very easily when being opened or closed.

Manufactured in angles, right and left hand corners and globes, one half to two inch sizes.

In satin finish with polished trim-

ings, nickel plated, Jenkins Brothers discs.

Detailed information including roughing-in dimensions on request.

Specify "Genuine Detroit" Packless Radiator Valves, Bellows Type.

Detroit Boiler Draw Off Cocks



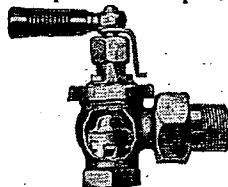
This improved cock has an outlet which is slightly inclined, to facilitate attachment of a hose, if desired.

It has a stuffing box which prevents any leakage and consequent flooding of floor when unscrewed.

The seat is a metal to metal and has been heavily reinforced, so that it cannot be distorted should excessive pressure be used when the cock is installed.

Specify "Genuine Detroit" Boiler Draw-off Cocks and get something better.

Detroit Improved Multiport Valve



A supply valve for use in vapor heating, with a self-contained double graduation.

One graduation, made at time of installation, adjusts inlet opening to pass the exact amount of vapor needed to meet the maximum requirements of the individual radiator to which it is attached.

The other graduation, that for heating any portion of the radiator desired, is attained by the movement of the lever handle between the range of "on" and "off" indicated on the dial.

The price is attractive.

Specify "Genuine Detroit" Multiport Valves for your vacuum work.

Pierce, Butler & Pierce Mfg. Corp.

Liggett Building

New York City

Factories: Eastwood, Syracuse and Oswego, N. Y.; Huntingdon, Pa.
Branch Offices: New York, Brooklyn, Syracuse, Newark, Worcester, Boston, Philadelphia, Detroit.

Radiator valves, high pressure valves, hot water valves, hot water thermometers, pressure gauges.

The Pierce Packless Valve

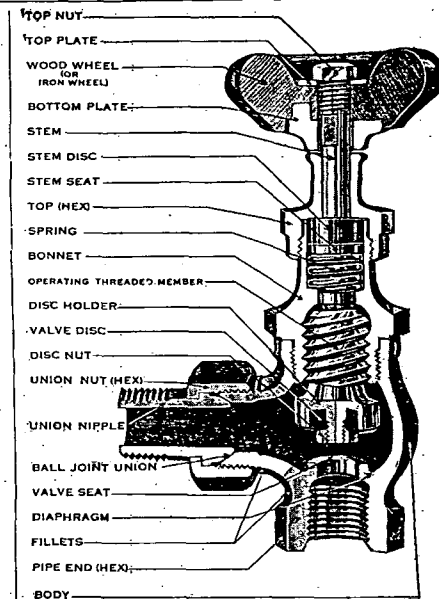
A Few of Its Outstanding Features

The stem disc (See the illustration) is made of fibre and is heat, steam and moisture proof. It is carried on a stem seat which is an integral part of the stem. This stem seat receives uniform pressure from a spring thereby seating and sealing the disc on the machined under-surface of the valve top. Steam and water cannot escape.

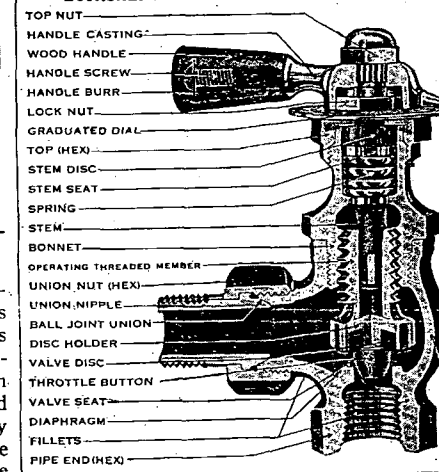
The steam disc can be renewed in a few minutes (if after years of service there appears need of renewal) without shutting off or interfering with the steam line.

The valve opens and closes with one turn of the handle. The type provided with lever handle graduated dial is widely used on vapor systems. Provision is made for modulation with exact relation to conditions.

The Pierce Valve is of heavy proportions with strong hex's and walls. It is made from high grade bronze castings and nickel plated before assembly, thereby avoiding deposits of nickel salts in working parts. Its joints are graphited before setting up and are accordingly easy to take apart. All parts are machined to precision under gauge limits and inspection.



Sectional View Valve with Wood Wheel



Valve with Lever Handle and Graduated Dial

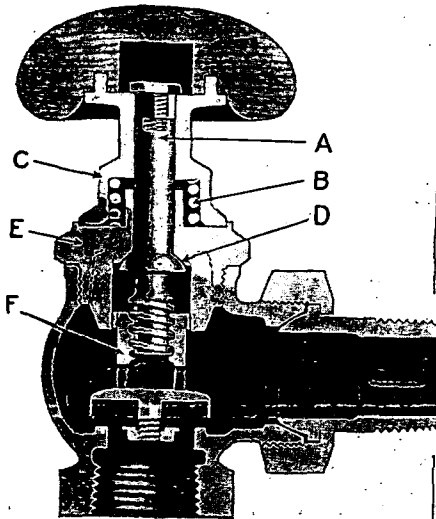
The Sandusky Packless Valve Co.

Sandusky, Ohio

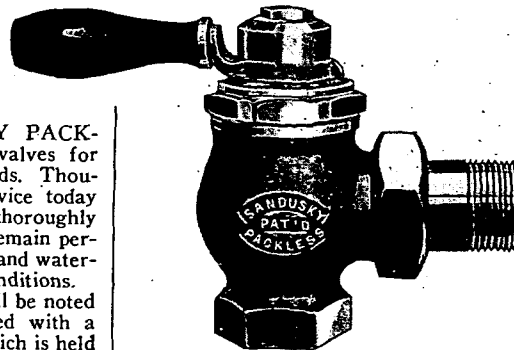
Sandusky Packless Radiator Valves for Steam, Hot Water, Vapor and Vacuum Heating Systems

The PACKLESS feature employed in the design of SANDUSKY PACKLESS RADIATOR VALVES is exactly the same as that used for the past five years in the construction of SANDUSKY PACKLESS globe, gate and angle valves for steam pressures up to 300 pounds. Thousands of these valves in service today under high pressure have thoroughly demonstrated their ability to remain permanently steam-tight, air-tight and water-tight under the most severe conditions.

By referring to the cut it will be noted that the stem (A) is provided with a hemispherical shoulder (D) which is held in contact with the 45 degree seat in the bonnet (E) by means of spring (B) acting on stem (A) through handle hub (C). The stem (A) is non-rising and when the valve is being opened or closed the hemispherical shoulder on the stem rotates on its seat in the bonnet. This forms a perfect metal to metal ground joint between the stem and bonnet at (D) and prevents any possibility of leakage around the stem.



Sectional View Fig. 31
Angle Type with Wood Wheel



Graduated Type with Lever Handle
Fig. 32

The SANDUSKY PACKLESS GRADUATED RADIATOR VALVE illustrated above fulfills in every way the requirements of an ideal valve of this type. They may be fully opened or closed with seven-eighths turn of the handle and are equipped with an indicator which is graduated to show the opening through the valve.

All SANDUSKY PACKLESS valves are guaranteed to give satisfactory inlet valve service and we stand ready AT ANY TIME to replace any SANDUSKY PACKLESS RADIATOR VALVE which should fail to give entire satisfaction.

List Prices and Roughing in Dimensions

FIGURE 31

Size	Center to Top	Center to Bottom	Center to End Tail Piece	List Price
3/4"	3 1/2"	1 1/2"	2 1/2"	\$ 3.90
1"	3 3/4"	1 3/4"	3 1/4"	4.70
1 1/4"	4 1/2"	1 7/8"	3 3/4"	6.25
1 1/2"	4 3/4"	2 1/4"	4 1/4"	8.15
2"	5"	2 3/4"	4 3/4"	13.00

FIGURE 32

Size	Center to Top	Center to Bottom	Center to End Tail Piece	List Price
3/4"	2 3/4"	1 1/4"	2 3/4"	\$4.80
1"	2 3/4"	1 1/4"	3 1/4"	5.75
1 1/4"	2 3/4"	1 1/4"	3 3/4"	7.40

Scott Valve Mfg. Co.

Detroit, Mich.

Manufacturers of Scott's High Grade Valves for Steam, Water, Air and Gas

Scott Exhaust Relief and Back Pressure Valves

The Scott water sealed Automatic Exhaust Relief and Back Pressure Valve shown below is one of the well-known Scott products. This valve is rigid in construction and it has been designed so that there are no parts that will become loose inside and foul the valve. The ample water seal makes it especially adapted for use with condensers and vacuum heating systems. The outside air cushioned dash pot gives it a positive cushion and makes it noiseless. Blue prints will be furnished to Engineers.

Scott Gate Valves

Scott Gate Valves are made in both brass and iron, in pressures in 100, 125, 150, 175 and 250 pounds and are also made for Hydraulic pressures up to 5,000 pounds.

These valves are fitted with the Scott cylindrical two-piece disc or solid wedge, and we can furnish the Michigan pattern with parallel seats if desired.

Chicago Hot Water Radiator Valves

These valves are heavier than most

Hot Water valves and can be connected without distortion. The tail pipe is long, so that the nut can be backed beyond the face of the joint, making connection easier. The cone below the stuffing box allows the valve to be packed under pressure and is more serviceable than most so-called Packless Valves.

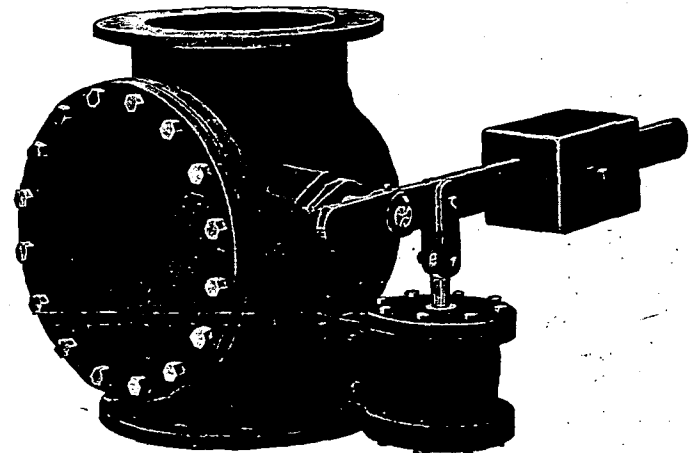
Scott Steam Radiator Valves

The steam valves are made with or without tail pipes in Angle, Globe, Off-Set, Corner (right or left) and with lock shields when desired. The construction is heavy and with long tail pipes. They are highly finished.

Scott Pop Safety Valves

Scott Pop Safety Valves have given excellent service for over thirty years. They are all that the name "Safety" implies. Long springs are used in them so that they will readily take care of excess pressure. The discharge capacities stamped on them is very conservative. The valves are made to A.S.M.E. specifications.

Besides the valves mentioned we can furnish valves for almost any purpose.



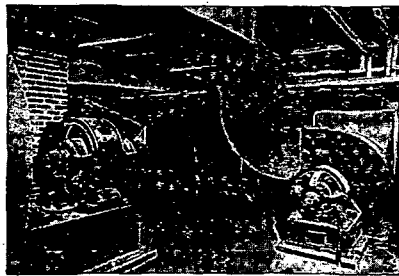
The Westinghouse Electric & Manufacturing Company

East Pittsburgh, Pennsylvania

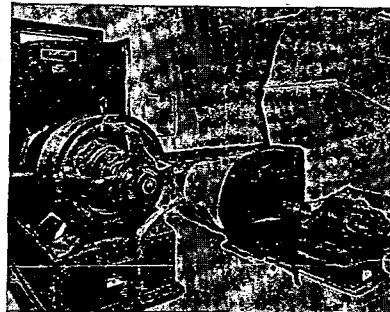
DISTRICT OFFICES:

Albany, N. Y.	Dayton, Ohio.	New Orleans, La.
Atlanta, Ga.	Denver, Colo.	New York, N. Y.
Baltimore, Md.	Des Moines, Ia.	Niagara Falls, N. Y.
Birmingham, Ala.	Detroit, Mich.	Philadelphia, Pa.
Bluefield, W. Va.	Duluth, Minn.	Pittsburgh, Pa.
Boston, Mass.	El Paso, Tex.	Portland, Ore.
Buffalo, N. Y.	Fresno, Calif.	Rochester, N. Y.
Butte, Mont.	Houston, Tex.	St. Louis, Mo.
Charleston, W. Va.	Indianapolis, Ind.	Salt Lake City, Utah
Charlotte, N. C.	Jacksonville, Fla.	San Francisco, Calif.
Chattanooga, Tenn.	Kansas City, Mo.	Seattle, Wash.
Chicago, Ill.	Louisville, Ky.	Syracuse, N. Y.
Cincinnati, Ohio	Los Angeles, Calif.	Tucson, Ariz.
Cleveland, Ohio	Memphis, Tenn.	Washington, D. C. (Gov. Office)
Columbus, Ohio	Milwaukee, Wisc.	Wilkesbarre, Pa.
Dallas, Tex.	Minneapolis, Minn.	Toledo, Ohio

Motors and Control for all Kinds of Ventilating Equipment, Elevators, Pumps, etc.



SK Motors Driving Ventilating Fans in Hotel Pennsylvania, New York.



Ventilating Equipment in Seaboard National Bank, New York.

The Westinghouse Electric & Manufacturing Company is in position to furnish complete electrical equipment for operating ventilating appliances, from the small blower for ventilating a single room to the automatic system for conditioning the air for the largest building.

The motors and controllers offered for this service have been especially designed to suit the power and speed characteristics of fans and blowers. At the same

time, quietness of operation has been retained.

The long experience of Westinghouse in making successful applications of ventilating equipments, is at the service of Heating and Ventilating Engineers and they are invited to submit their ventilating problems to us for recommendations of electrical equipment that will produce the most satisfactory results at minimum cost.

Data Desired in Applying Ventilating Motors

Kind of Current. A. C.—Voltage, Phase, Frequency. D. C.—Voltage.

Type, make, speed and size of fan or blower.

Motor speed.

Constant or Varying Speed. If the latter, the speed range and horse-power required at normal or maximum speed.

Method of Connection.

Intermittent or Continuous Service.

The Patterson-Kelley Co.

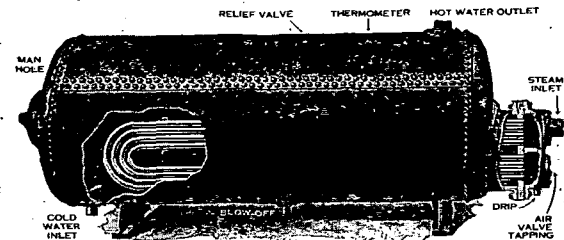
101 Park Avenue

New York City

Preheaters, Heat Exchangers, Heaters for Chemicals, Gases, Oils. Coolers for Brine, Chemicals, Gases, Oil and Water. Hot Water Heaters for all purposes. Pool Heaters and Converters.

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.



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 'N' shaped to provide against contraction and expansion. 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.

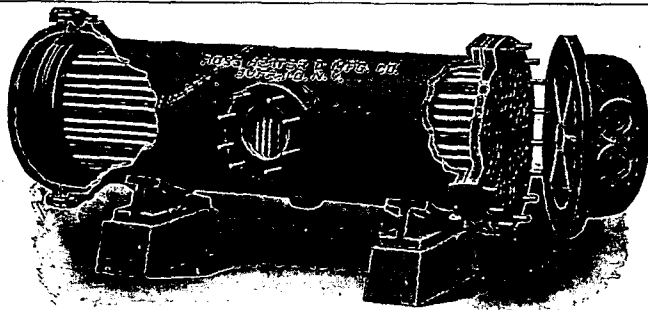
No.	Gallons per Hour	Approx. Wt. in Lbs.	No.	Gallons per Hour	Approx. Wt. in Lbs.
1 H	100	200	15 H	2000	700
2 H	150	215	16 H	2500	800
3 H	200	235	17 H	3000	900
4 H	250	255	18 H	3500	1050
5 H	300	285	19 H	4000	1200
6 H	400	315	20 H	4500	1350
7 H	500	350	21 H	5000	1500
8 H	600	370	22 H	6000	1750
9 H	700	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.

Ross Heater & Mfg. Co. Buffalo, N. Y.

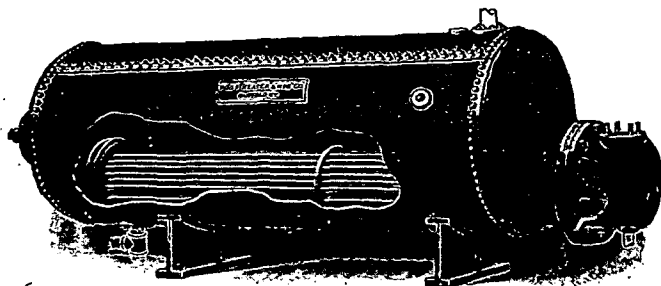
Represented in all principal cities.

Heaters, Condensers, Coolers, Strainers, Heat Exchangers and
Expansion Joints for all services.



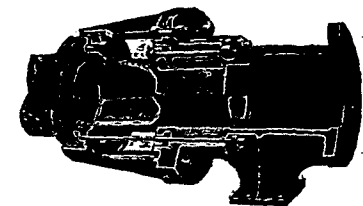
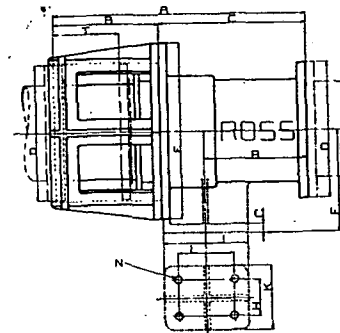
Ross Radial Flow Instantaneous Heater

Instantaneous Heaters cover a very wide field; in fact a large per cent. of services can be taken care of with this type even though no attempt is made to carry a supply of the heated liquid in reserve or storage. A few of the services are: Hot water service supply for hotels, factories, hospitals, schools, apartment buildings, etc. Water for hot water heating systems for either forced or gravity circulation. Oil for pipe lines, storage stations, fuel oil burning apparatus, etc. Boiler feed water for high or low pressure. Water for swimming pools. Sugar juice in cane or beet sugar houses. Chemical compounds of all kinds, etc. Straight tubes are used and they are accessible at both ends.



Ross Storage Type Heater

The Ross Storage Heater meets a condition where it is desirable to store up and have in reserve a supply of hot water. This heater is made in various combinations of storage tanks and heating elements so as to meet any condition of service. The heating element is located on the bottom and extends practically the full length of the tank. The entire heating element can be removed for cleaning or repairs. The tubes are straight and expanded into both tube sheets, one of which is of the floating type.



Sectional view Ross Crosshead-Guided
single expansion joint.

The Ross Crosshead-Guided Expansion Joint is a high grade fitting for taking care of the expansion and contraction in pipe lines due to changes in temperature. These Ross fittings are made for all pipe sizes. The above sectional view shows the construction, the principal feature being the guiding of the slip tube to insure perfect alignment in its travel through the packing box, which is extra deep. The periphery of the slip tube flange is machined to an accurate fit with the machined inner surface of the guide. Accessibility to the packing box is obtained by unbolting the guide from the main body flange and shoving it back over the main pipe. The flanges are of the well-known Van Stone type. The Ross fitting can be packed without removing same from the pipe line. It is provided with limit rods to prevent the slip tube pulling out of the packing box. All holes drilled from templates—not cored.

The Ross Crosshead-Guided Expansion Joint is suitable for pipe lines conveying saturated or superheated steam, water, oil, air, or any fluid subjected to changes in temperature. These fittings are built in three general types—Low Pressure Cast Iron for pressures of 125 pounds and lower; High Pressure Cast Iron for pressures from 125 to 250 pounds; High Pressure Cast Steel for extra high pressures and temperatures. All of the above types of joints can be supplied either in the single or double fitting and with or without anchor bracket. The length of traverse varies from 4" to 16", depending upon the size and type of fitting.

The following table gives the dimensions in inches of the more popular sizes of single expansion joints. These dimensions referring to the above line cut.

Dimensions Ross Single Low Pressure Expansion Joints

Size Joint	Traverse T	A	B	C	E	F	G	H	K	J	L	N	R	Flange Dia.	D Bolts		
															Size	to Z	to O
3	4	14 1/4	7	7 1/4	10 1/4	5 1/4	7 1/8	2 1/2	4 1/2	5	2 1/2	5 1/2	4 1/2	7 1/4	5/8	4	6
3 1/2	4	15 1/4	7 3/4	7 3/4	11 1/4	6	7 1/2	2 1/2	4 1/2	5	2 1/2	5 1/2	4 1/2	8 1/4	5/8	4	7
4	4	16 1/4	8	8	12 1/4	6 1/2	7 1/2	2 1/2	4 1/2	5	2 1/2	5 1/2	4 1/2	9 1/4	5/8	8	7 1/2
4 1/2	4	16 1/2	8 1/2	8 1/2	12 1/2	6 3/4	7 3/4	2 1/2	4 1/2	5	2 1/2	5 1/2	4 1/2	9 1/2	5/8	8	7 3/4
5	4	16 3/4	8 3/4	8 3/4	13	7	7 3/4	2 1/2	4 1/2	5	2 1/2	5 1/2	4 1/2	10	5/8	8	8 1/2
5 1/2	4	17 1/4	9 1/4	9 1/4	13 1/4	7 1/2	8 1/4	2 1/2	4 1/2	5	2 1/2	5 1/2	4 1/2	10 1/2	5/8	8	9 1/2
6	8	24 1/4	11 1/4	11 1/4	16 1/4	8 1/4	9 1/4	3 1/2	6	6 1/4	3 1/2	5 1/2	4 1/2	12 1/2	5/8	8	10 1/4
7	8	24 1/2	11 1/2	11 1/2	16 1/2	8 3/4	9 3/4	3 1/2	6	6 1/2	3 1/2	5 1/2	4 1/2	12 1/2	5/8	8	10 1/2
8	8	26	12	12	17 1/2	9 1/4	10 1/4	3 1/2	6	6 3/4	3 1/2	5 1/2	4 1/2	13 1/4	5/8	8	11 1/4
9	8	27 1/4	12 1/4	12 1/4	20 1/4	10 1/4	10 3/4	3 1/2	6	7 1/4	3 1/2	5 1/2	4 1/2	15	5/8	12	13 1/4
10	8	27 1/2	12 1/2	12 1/2	21	10 3/4	11 1/4	3 1/2	6	7 1/2	3 1/2	5 1/2	4 1/2	16	5/8	12	14 1/4
12	8	27 3/4	11 3/4	15 3/4	24 3/4	12 3/4	14	6	10	10 1/4	6	5 1/2	4 1/2	19	5/8	12	17

Dimensions Ross Single High Pressure Expansion Joints

Dimensions (See Page 10) - Flange to Face of Bolt Circle																	
3	8	25	11½	13½	13½	7	¾	3	5	5¼	3	5½	10	8¼	¾	8	6½
3½	8	26	12	14	14	7¾	¾	3¾	6	6¼	3¾	5¼	10	9	¾	8	7½
4	8	26	12¼	13¾	15	7¾	¾	3¾	6	6¼	3¾	5¼	10	9¼	¾	8	7¾
4½	8	26	12½	13¾	15½	8¼	¾	3¾	6	6¼	3¾	5¼	10½	9½	¾	8	8½
5	8	27¼	12½	14¾	17	8¾	¾	3¾	6	6¼	3¾	5¼	10¾	11	¾	8	9¼
5½	8	26¾	12½	14	18½	9½	¾	5	8	8¼	5¼	1	12½	¾	12	10¾	
6	8	27½	13	14½	20	10½	1	5½	8	8¼	5¼	1	9¼	14	¾	12	11½
7	8	29¼	13¾	15½	21½	11½	1	5½	8	8¼	5¼	1	10½	15	¾	12	13
8	8	30	14½	16½	23¼	12½	1	5½	9	10	5½	1	9¼	16½	1	12	14
9	8	30	14½	16½	23¼	12½	1	5½	9	10	5½	1½	9¼	17½	1	16	15¼
10	8	30	14½	16½	23¼	12½	1	5½	9	10	5½	1½	9¼	17½	1	16	15¼
12	8	31	15	17	27½	14	1	5½	9	10	5½	1½	10	20½	1½	16	17¼

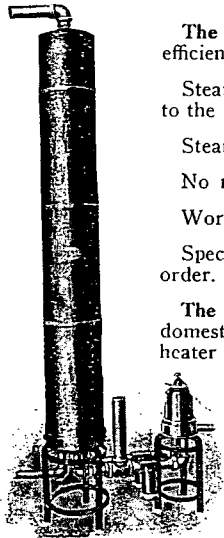
Stack Heater Co.

Boston, Mass.

Engineers

Manufacturers

Water Heaters for All Domestic and Industrial Requirements



The Stack Instantaneous Steam Water Heater is a simple, yet efficient device, for supplying clean hot water.

Steam does not mix with the water, it merely transfers its heat to the water in the copper tubes.

Steam is used only while water is being drawn.

No moving parts or expansion joints.

Works efficiently on exhaust or high pressure steam.

Special Stack Instantaneous Steam Water Heaters are built to order. Full information will be furnished upon request.

The Stack Indirect Heater, at practically no cost, heats the domestic hot water to a uniform temperature, using the house heater as a heating medium.

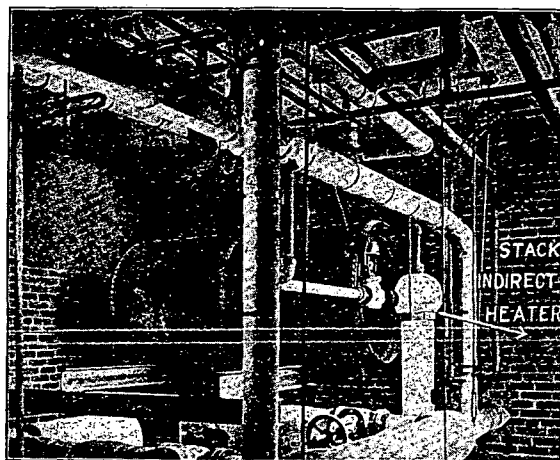
The domestic hot water passes through the copper coil in the heater and the hot water from the house heating plant flows around the copper coil.

The two waters never mix.

All coils tested to 600 pounds pressure and the casings tested to 250 pounds pressure at our factory.

Full information, including installation diagrams, will be furnished upon request.

Instantaneous Steam Water Heater (Capacities 10 to 2000 gal. per minute)



Boiler Room, Trumbull Hospital, H. F. Kellogg, Arch. Installed by Eastern Power & Heating Corp.

Construction of Indirect Water Heater, showing the Copper Tubes within the Shell. This Heater is made in all sizes.



Thermal Appliance Co.

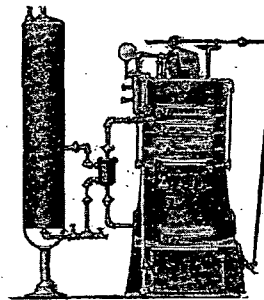
342 Madison Ave.

New York, N. Y.

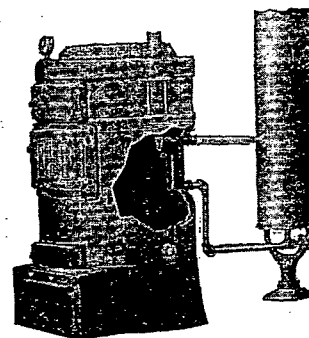
"TACO" WATER HEATERS

for Domestic Service

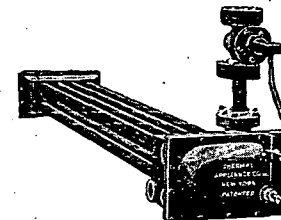
and for Hotels, Apartment Houses, Institutions, Mills, Factories, Industrial Plants and Restaurants



Standard Domestic "Taco" Heater Installation. Note the simple piping.



Universal "Taco" Water Heater as installed.



"Taco" Automatic Heater Built in both high and low pressure types in 12 sizes from 100 to 10,000 gallons per hour capacity.

Domestic TACO Water Heaters (External Type)
for use with steam heating boilers

Size No.	Range Suitable for Gals.	Shipping Weight Lbs.	List Price
Special	30	12	\$15.00
1	40	18	20.00
2	80	28	30.00
3	160	53	50.00

Flo-Line TACO Water Heaters (External Type)
for use with steam or hot water heating boilers

Size No.	Range Suitable for Gals.	Shipping Weight Lbs.	List Price
01	60	20	\$25.00
02	120	40	35.00
03	240	80	55.00

TACO Universal (Firepot Type) Water Heaters

for connection to steam or hot water house heating boilers. Made of malleable iron, tested to 250 pounds pressure.

Size No.	Type, Studs on centers as below	Range Boiler Suitable for Gals.	List Price
9-30	6"	30	\$8.00
9-60	6"	60	14.00
6-9-30*	None	30	8.00
6-9-60*	None	60	14.00
3-30†	None	30	8.00
3-60†	None	60	14.00

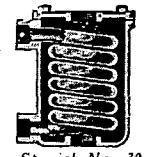
* Will fit any boiler with either 6, 9, or more inch center to center coil openings.

† Will fit sectional boilers with 3 inch center to center coil openings or can be used with hot air furnaces.

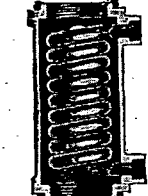
TACO Automatic Water Heaters

for supplying hot water in quantity.

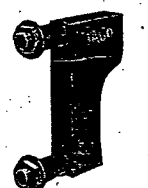
Heat water as it flows through. Operate on live or exhaust steam. Used with or without storage tank. Automatic thermostatic valve control. Prices on request.



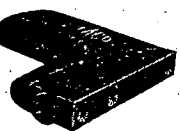
Special No. 30 Domestic "Taco"



No. 02 Flo-Line "Taco" Heater



No. 9-30 Universal "Taco"



No. 6-9-60 Universal "Taco"

Anti-Corrosion Engineering Co., Inc.

117 West 54th Street,
New York, N. Y.

Apparatus for Removing and Preventing Rust in Hot and Cold Water Systems

Deactivation

Substantially all of the internal corrosion, pitting, bursting and choking of domestic hot water systems, and much of the destructive internal corrosion of economizers, feed systems, boilers, etc., of power and industrial plants, is caused by the action of FREE DISSOLVED OXYGEN in the water. The removal of this oxygen renders the water non-corrosive; our process is termed "DEACTIVATION"; the water is termed "DEACTIVATED WATER."

Free oxygen is carried by all natural waters as a constituent of the air which dissolves from the atmosphere. The amount of oxygen is usually enough to saturate the water and depends principally upon temperature and pressure and to a small degree upon the salts in the water. The curve herewith gives the solubility of oxygen in pure water from zero to atmospheric pressure and from

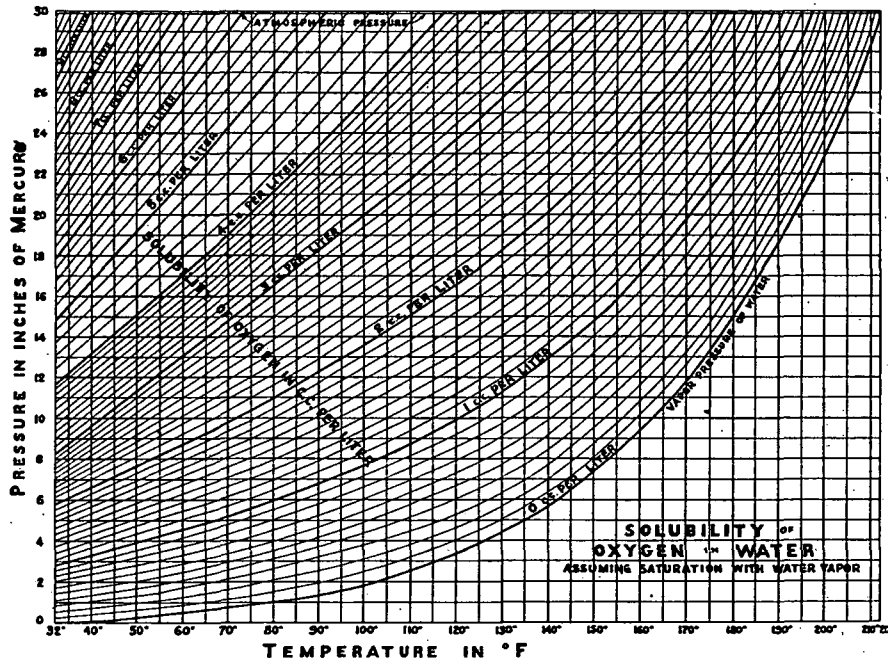
zero to 212 degrees F. For other pressures the solubility is about in proportion to the pressure.

Metals 20 per cent. eaten away by rust are generally useless and cost about \$2.00 per pound to replace, so that 1,000 gallons of raw water may cause \$7.50 worth of damage.

The removal of this free oxygen reduces corrosion in proportion to the per cent. of oxygen removed. Our apparatus removes 90 to 95 per cent. and is guaranteed to remove 85 per cent.

Among the many installations where deactivation is saving pipe are the following:—

Hudson Terminal Buildings, New York City.
Land Title Building, Philadelphia.
Passyunk Operation (500 houses) of the Girard Estate, Philadelphia.
Bonnie Burns Sanitarium, New Jersey.
United Engineering Societies Building, New York City.
Power Plant installations for Stone & Webster.



Deaerating Deactivator

The machine shown below is for removing the free dissolved oxygen from water, thereby rendering it non-corrosive, without the use of chemicals. This gas-free water is used in domestic systems and for power and industrial plants. In domestic systems it prevents corrosion, removes accumulated rust in old pipes and obviates air slugs and air binding. In power plants it prevents corrosion, stops scoring and increases condenser efficiency. In the industries it prevents rust discoloration of products.

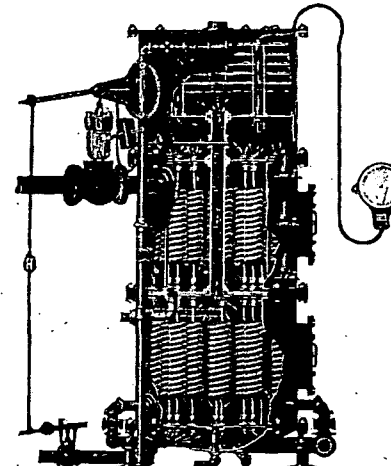
Principle of Operation

The water to be treated is heated to a temperature just below boiling point and is then thoroughly agitated by spraying over a series of pans in the top section. Under this treatment the gases bubble out and are carried away by a vent to the atmosphere. The treated water is cooled as it leaves the machine by an exchange of heat with the incoming raw water in the bottom section. This partially heats the raw water, which is then brought up to an automatically controlled and recorded temperature in the low pressure steam heater or center section. Constant water level is maintained by an automatic governor attached to the raw water inlet.

Construction

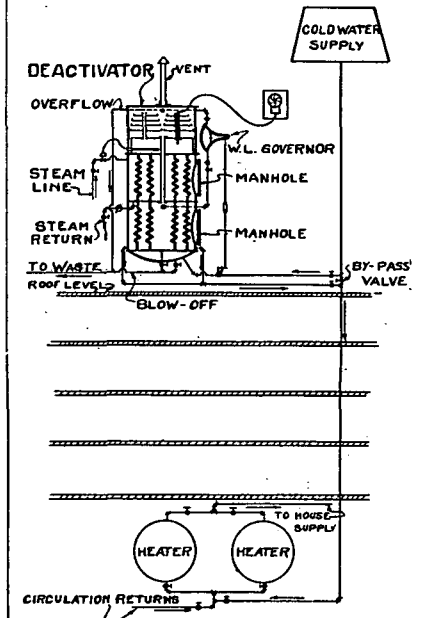
Shells of steel, fully protected from raw water by high temperature enamel or copper sleeves. All exchanger and heater coils of copper. All other internal parts of cold rolled copper or bronze.

This apparatus may be set on the roof, or upper floors, sufficiently high to deliver the treated water by gravity, or in the basement with a pump for delivery.



In the application shown by the small diagram, raw water is bypassed from a roof tank through the machine and thence out and down to the heaters in basement, thus protecting heaters and all piping. This type of apparatus is especially applicable where a constant supply of steam is available.

Full specifications, capacities, dimensions, weights, etc., will be provided upon request.



Deoxidizing Deactivator

This apparatus is based on the principle of forcing the water to expend its corrosive power on cheap material in an accessible place instead of on valuable and inaccessible pipe.

The water to be rendered non-corrosive is first heated in any suitable manner—steam, coal or gas heaters. It then passes into a tank which is almost completely filled with deactivating material. There the hot water produces all the rust it can, the rust falling to the bottom of the tank or adhering to the deactivating material.

In order that the water may not carry finely divided particles of rust in suspension, it first passes through a coagulate tank before it enters the heater. In this tank it absorbs a minute quantity of co-

agulite—just sufficient to coagulate the particles of rust, thus insuring clear water.

In small supply systems designed to operate at low velocities, no further apparatus is required to produce non-corrosive water. In the case of large buildings in which sudden peak loads may occur, this apparatus is used in conjunction with a filter. Anti-corrosion filters are especially designed for use on hot water and have a very low internal resistance.

The apparatus is generally located in the basement near the hot water heater. It is connected to the sewer lines so that the deactivating tank and the filter can be blown off and washed out as required.

The Deoxidizing Deactivator can be used with steam, coal or gas as the source of heat. Modifications of this apparatus can be had to meet any condition.

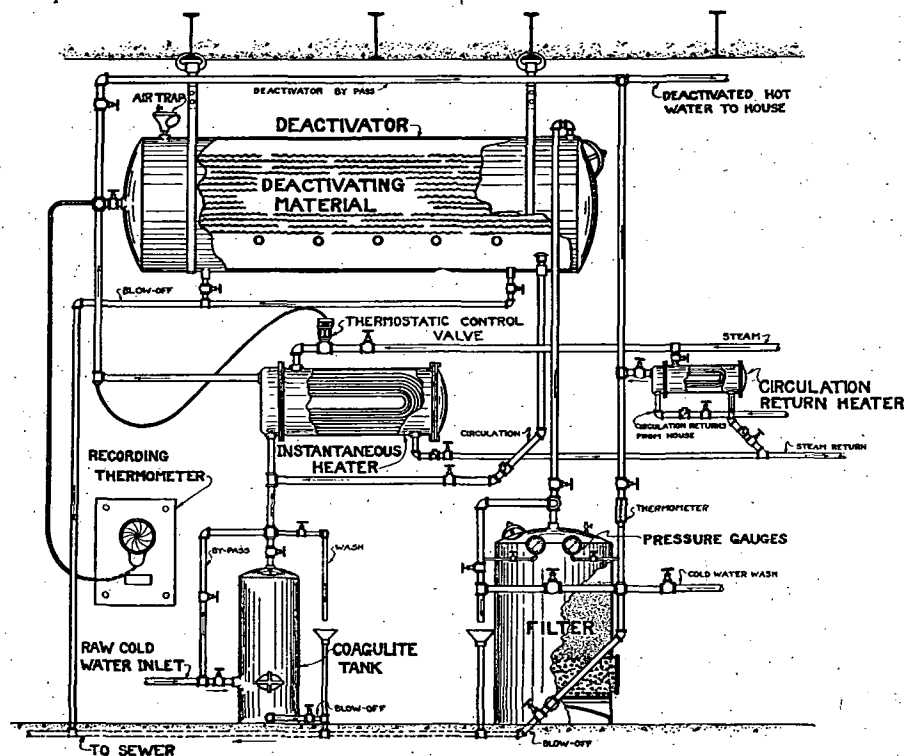
Specifications, capacities, dimensions, weights, etc., will be provided upon request.

How To Estimate Hot Water For Buildings

Allow per H. W. fixture per day—For apartments, 25 gallons for high class, 20 gallons for medium class, and 15 gallons for tenements. For transient hotels, 60 to 80 gallons. For apartment hotels, 40 to 50 gallons. For institutions, 50 to 75 gallons. For offices with private basins in rooms, 15 to 20 gallons; and for offices without private basins in rooms, 40 to 50 gallons.

Allow for maximum hour demand in percentage of daily consumption, 10 per cent. for apartments, apartment hotels, institutions and offices, and 7 per cent. for transient hotels.

Add for laundries one gallon per piece of laundry, and for kitchens one gallon per maximum hour per person served.



Deoxidizing Deactivator Type B 4

The Permutit Company

440 Fourth Ave.

New York

Apparatus for removing hardness from water and preventing the formation of scale in hot or cold water systems

Soft Water for Every Purpose

A Permutit Water Softener will give your clients a bountiful supply of sparkling soft water for any purpose, either personal or industrial, no matter how hard and unsatisfactory the available supply is.

Size

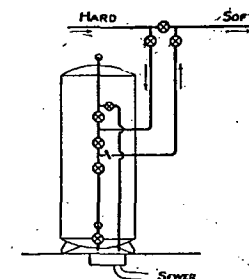
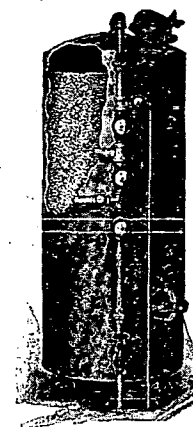
A Permutit Water Softener is a metal shell or tank, containing Permutit material, that is connected into the house supply line. It is offered in two sizes and six styles, which give an unlimited range of capacities according to the hardness of the water and quantity to be softened. Largest size requires 3'-0" x 6'-6" floor space and 6'-0" head room. Smallest size 2'-0" x 5'-6" floor space and 6'-0" head room. This includes necessary room for operation.

Regeneration

Permutit material is not consumed by the softening process, but is regenerated periodically and used for an indefinite length of time. When it has softened its designated quantity of water, common cooking salt is run through the Permutit bed. The salt restores the Permutit material to its original condition, and after draining off the surplus, it is in exactly the same condition it was at the beginning. The amount of attention required is but a few minutes a week, and anyone can learn to turn the necessary valve correctly.

Capacity

Softeners are customarily designed with capacities to operate a week to ten days between regenerations. Meters are not included in standard equipment but are furnished on order, as most houses have meters. Where no meters are used, the time for regeneration is determined by a soap test that is simple and accurate.



Location

Softeners may be located in the basement or any other convenient spot, and can be connected into the water supply line by any plumber. They are usually placed directly in the main feed line with a simple by-pass arrangement of valves.

Sewer Connection

Sewer connection is customarily in the form of an open sump to avoid the backing up of sewer gases, but it is not necessarily confined to that form.

Pressure

Standard designs are constructed to operate under pressures up to 100 lbs. per sq. inch. The normal pressure drop through the Softener does not exceed 5 lbs.

Material and Workmanship

Softener shells are made of steel. All valves are of the Crane and Jenkins standard, and workmanship throughout is the highest quality. Our many refinements in design and construction make a Permutit Softener a permanent and dependable fixture that will outlast the plumbing system into which it is connected.

Information Required for Estimates

To properly estimate the size, capacity and cost of a Permutit Water Softener for any household the following information is required:

1. Number of people in house (including servants if any).
2. Height of ceiling in basement or other location.
3. Source of water supply, i.e., city, well, river, lake, etc.

If the water supply is that of any good sized city we have an analysis in our files, otherwise we need a half-gallon sample of the water, forwarded in glass or earthenware.

INDICES

**Index to
Society Standards
Committee Reports
and
Technical Papers from the
Society's Transactions**

	PAGE
Report of Special Committee on Standards for Flanged Fittings and Flanges	10
Report of Committee on Standardization of the Use of the Pitot Tube	13
Report of Committee on Standard Method of Measuring the Velocity of air through Warm Air Registers when the Anemometer is Used.....	17
Report of Committee on Temperature Code for Testing Heating Systems	17
Synthetic Air Chart.....	18
Modus Operandi of the Synthetic Air Chart.....	19
Code for Testing Low Pressure Heating Boilers, Revision of 1919	27
Report of Committee on Uniform Contract and Specifications	31
Report of Committee on Code for Testing Direct Radiation Heating Plants	31
Report of Committee on Standard Sizes of Steam and Return Mains	31
Report of Committee on Minimum Ventilation Requirements for Public and Semi-Public Buildings for Legislation Purposes	32
Report of Committee on Code of Ethics.....	33
Report of Committee on Automatic Heat Control.....	34
An Ordinance for Construction of Chimneys.....	35
High Temperature Drying.....	49
<i>Burt S. Harrison</i>	
The Temperature of Evaporation.....	61
<i>Willis H. Carrier</i>	
Comparison of Pipe Coils and Cast Iron Sections for Warming Air	83
<i>John R. Allen</i>	
Theory of Heat Losses from Pipes Buried Deeply in the Ground	84
<i>John R. Allen</i>	
Water Pipe Sizes for Plumbing Fixtures, Branches and Mains	89
<i>Walter S. Timmis</i>	
Recent Developments in Warm Air Furnace Heating.....	96
<i>F. R. Still</i>	

**Index to
General Data Section**

	PAGE
Introduction	107
Heat Losses from Buildings.....	109
Window Leakage	110
<i>Stephen F. Voorhees and Henry C. Meyer, Jr.</i>	
Transmission Constants for Building Materials.....	113
A Test of the Conductivity of Window Shades.....	116
<i>John R. Allen</i>	
Selection of Radiation.....	118
Heat Emitted by Direct Radiation:	
Single-Column Radiators	119
Two-Column Radiators	120
Three-Column Radiators	121
Four-Column Radiators	122
Hospital Radiators—Two-Column	123
Wall Radiators	124
Window Radiators	125
Conversion Factors	126
Heating Surface, Standard Cast Iron Radiation.....	127
Effect of Humidity on Heat Transmission from Radiators.....	128
Effect of Air Circulation.....	128
Effect of Painting.....	128
Warming the Radiator.....	129
Effect of Enclosing the Radiator.....	130
Effect of Position of Radiator.....	132
Heat Losses from Buildings.....	133
The Boiler	135
Chimneys	135
Some Causes of Poor Draft in Chimneys.....	136
Pipe Sizes for Steam Heating.....	137
Tables Pages 139 to 145, inc.	
Flow of Steam in Pipes.....	146
Methods of Equalizing Boilers.....	147
Water Hammer	147
Care of Steam Boilers.....	148
Pipe Sizes for Gravity Hot Water Heating.....	149
Friction of Water in Iron Pipes and Elbows.....	149
Expansion Connections	150
Steam Connections	151
Typical Radiator Connections.....	152
Dimensions and Capacities Steam Vacuum Pumps.....	153
Pump Suction Lifts.....	153
Properties of Saturated Steam.....	154
Useful Data	155
Circumferences and Areas of Circles.....	159
Systems of Weights and Measures.....	160
Properties of Air.....	164
Psychrometric Charts:	
Low Temperature	183
High Temperature	184
Psychrometric Tables	185-192

Modern Engineering and Equipment Practice

(Pages 193 to 210, inc.)

Directory of Consulting Engineers

(Pages 212 and 213)

Catalog Data Section

(Pages 215 to 349, inc.)

(See Index to Advertisers)

Index to Modern Equipment

AIR COMPRESSORS, ELECTRIC AND HYDRAULIC		BOILER FEEDERS	
	PAGE		PAGE
Johnson Service Co.....	257-261	Warren Webster & Co.....	323
AIR CONDITIONING EQUIP- MENT		COLLECTORS, DUST	
American Blower Co.....	267	Buffalo Forge Co.....	268
Atmospheric Conditioning Corp.....	216-217	Carrier Construction Co.....	298
Carrier Air Conditioning Co. of America.....	268	Hersh Bros. Co.....	270-271
Carrier Engineering Corp.....	218-219	York Heating & Ventilating Corp.....	284
Drying Systems, Inc.....	264-265	CONDENSERS	
W. L. Fleisher & Co.....	220	Ross Heater & Mfg. Co.....	342-343
AIR WASHERS		COOLERS, BRINE	
American Blower Co.....	267	Patterson-Kelly Co.....	341
Bayley Manufacturing Co.....	280	Ross Heater & Mfg. Co.....	342-343
Buffalo Forge Co.....	268	DAMPERS, FIRE	
Carrier Air Conditioning Co. of America.....	268	Carrier Construction Co.....	298
Hersh Bros. Co.....	270-271	DAMPERS, MIXING	
B. F. Sturtevant Co.....	273	Carrier Construction Co.....	298
BAKING EQUIPMENT, HIGH TEMPERATURE		Powers Regulator Co.....	228-230
Drying Systems, Inc.....	264-265	York Heating & Ventilating Corp.....	284
BLOWERS		DEHUMIDIFIERS	
(See Fans)		(See Air Conditioning Equipment)	
BOILERS		DIFFERENTIAL LOOPS	
Ames Iron Works.....	221	Hoffman Specialty Co.....	304-315
American Radiator Co.....	274-279	DRYING EQUIPMENT	
Continental Heater Corp.....	222-223	American Blower Co.....	267
J. F. Davis & Sons Co.....	224	Atmospheric Conditioning Corp.....	216-217
Fitzgibbons Boiler Co., Inc.....	226-227	Buffalo Forge Co.....	268
International Heater Co.....	228-232	Carrier Engineering Corp.....	218-219
Kewanee Boiler Co.....	234-239	Drying Systems, Inc.....	264-265
Keystone Boiler & Foundry Co.....	225	W. L. Fleisher & Co.....	220
Monitor Bi-Loop Radiator Co.....	240-241	B. F. Sturtevant Co.....	273
L. J. Mueller Furnace Co.....	233	DRYING EQUIPMENT, VARNISH	
Oil City Boiler Works.....	242-243	Drying Systems, Inc.....	264-265
Wm. H. Page Boiler Co.....	244	ELECTRICAL EQUIPMENT	
Pierce, Butler & Pierce Mfg. Corp.....	245-337	Sprague Electric Works.....	266
Prudential Heater Co.....	246	Westinghouse Electric & Mfg. Co.....	340
Reading Heater & Supply Co.....	247		
Richardson & Boynton.....	248		
H. B. Smith Co.....	350-353		
Standard Heater Co.....	249		
Thatcher Furnace Co.....	256		
United States Radiator Corp.....	254-255		

ENGINES, STEAM

	PAGE
American Blower Co.....	267
Ames Iron Works.....	221
Buffalo Forge Co.....	268
Pierce, Butler & Pierce Mfg. Corp.....	245-337
B. F. Sturtevant Co.....	273

EXHAUSTERS

(See Fans)

EXPANSION JOINTS

American District Steam Co.....	299
Ross Heater & Mfg. Co.....	342-343
Warren Webster & Co.....	323

FANS

American Blower Co.....	267
Bayley Mfg. Co.....	280
Buffalo Forge Co.....	268
Electric Blower Co.....	269
Hersh Bros. Co.....	270-271
Ilg Electric Ventilating Co.....	281
B. F. Sturtevant Co.....	273
Westinghouse Electric & Mfg. Co.....	340

FURNACES, AUTOMATIC

Automatic Furnace Co.....	324
Murphy Iron Works.....	325

GOVERNORS, PUMP

Kieley & Mueller, Inc.....	316
----------------------------	-----

GAGES, MERCURY

American District Steam Co.....	299
---------------------------------	-----

GAGES, VACUUM PRESSURE

O.-E. Specialty Mfg. Co.....	319
------------------------------	-----

HANGERS, RADIATOR

Fowler & Wolfe Mfg. Co.....	294
Healy-Ruff Co.....	296
Minnesota Radiator Co.....	295

HEATERS, INDIRECT

American Blower Co.....	267
American Radiator Co.....	274-279
Bayley Mfg. Co.....	280
Buffalo Forge Co.....	268
Carrier Engineering Corp.....	218-219
B. F. Sturtevant Co.....	273

HEATERS, LIQUID

Patterson-Kelly Co.....	341
-------------------------	-----

HEATERS, SPECIAL

Patterson-Kelly Co.....	341
Ross Heater & Mfg. Co.....	342-343

HEATING AND VENTILATING EQUIPMENT

	PAGE
American Blower Co.....	267
American Radiator Co.....	274-279
Atmospheric Conditioning Corp.....	216-217
Bayley Mfg. Co.....	280
Buffalo Forge Co.....	268
Carrier Air Conditioning Co. of America.....	268
Carrier Engineering Corp.....	218-219
W. L. Fleisher & Co.....	220
Hersh Bros. Co.....	270-271
Ilg Electric Ventilating Co.....	281
International Heater Co.....	228-232
Herman Nelson Corp.....	282-283
B. F. Sturtevant Co.....	273
York Heating & Ventilating Corp.....	284

HUMIDIFIERS

(See Air Conditioning Equipment)

Bahnsen Co.....	285
-----------------	-----

INSULATING MATERIALS

Celite Products Co.....	286
Robt. A. Keasbey Co.....	287

METERS, STEAM

American District Steam Co.....	299
---------------------------------	-----

METERS, WATER

H. S. B. W.-Cochrane Corp.....	262-263
--------------------------------	---------

MOTORS, DIAPHRAGM

Fulton Co.....	334-335
Johnson Service Co.....	257-261
Powers Regulator Co.....	328-330

MOTORS, ELECTRIC

Sprague Electric Works.....	266
B. F. Sturtevant Co.....	273
Westinghouse Electric & Mfg. Co.....	340

OUTLETS, AIR

Carrier Construction Co.....	298
York Heating & Ventilating Corp.....	284

PIPE FITTINGS

Crane Co.....	288-290
---------------	---------

PIPING, INDUSTRIAL

Carrier Engineering Corp.....	218-219
-------------------------------	---------

PUMPS

Buffalo Steam Pump Co.....	291
Nash Engineering Co.....	292
Thermograde Valve Co.....	321
Trane Co.....	293-322
Westinghouse Electric & Mfg. Co.....	340

RADIATORS

	PAGE
American Radiator Co.....	274-279
Fowler & Wolfe Mfg. Co.....	294
Kewanee Boiler Co.....	234-239
Minneapolis Radiator Co.....	295
Monitor Bi-Loop Radiator Co.....	240-241
Pierce, Butler & Pierce Mfg. Corp.....	245-337
Reading Heater & Supply Co.....	247
H. B. Smith Co.....	350-353
U. S. Radiator Corp.....	254-255

REGISTERS

L. J. Mueller Furnace Co.....	233
-------------------------------	-----

REGULATORS, DAMPER

Carrier Engineering Corp.....	218-219
Fulton Co.....	334-335
Johnson Service Co.....	257-261
Powers Regulator Co.....	328-330

REGULATORS, HUMIDITY

American Blower Co.....	267
Atmospheric Conditioning Corp.....	216-217
Carrier Engineering Corp.....	218-219
W. L. Fleisher & Co.....	220
Johnson Service Co.....	257-261

REGULATORS, PRESSURE

Fulton Co.....	334-335
Minneapolis Heat Regulator Co.....	327

REGULATORS, TEMPERATURE

American Blower Co.....	267
Atmospheric Conditioning Corp.....	216-217
Carrier Engineering Corp.....	218-219
Donnelly Systems Co.....	302
W. L. Fleisher & Co.....	220
Fulton Co.....	334-335
Honeywell Heating Specialties Co.....	326
Johnson Service Co.....	257-261
Minneapolis Heat Regulator Co.....	327
Powers Regulator Co.....	328-330
Sarco Co., Inc.....	297

REGULATORS, WATER

Fulton Co.....	334-335
----------------	---------

ROTARY HACK SAW TOOLS

Excelso Specialty Works.....	303
------------------------------	-----

SEPARATORS, OIL

H. S. B. W.-Cochrane Corp.....	262-263
Warren Webster & Co.....	323

SEPARATORS, STEAM

H. S. B. W.-Cochrane Corp.....	262-263
--------------------------------	---------

SHEET METAL WORKERS

	PAGE
Carrier Construction Co.....	298
L. J. Mueller Furnace Co.....	233
B. F. Sturtevant Co.....	273
York Heating & Ventilating Corp.....	284

SPECIALTIES, HEATING

American District Steam Co.....	299
Donnelly Systems Co.....	302
C. A. Dunham Co.....	300-301
Excelso Specialty Works.....	303
Fulton Co.....	334-335
Hoffman Specialty Co.....	304-315
Johnson Service Co.....	257-261
Kieley & Mueller, Inc.....	316
McAlear Mfg. Co.....	317
Monash-Younger Co.....	318
O.-E. Specialty Mfg. Co.....	319
Pierce, Butler & Pierce Mfg. Corp.....	245-337
Sterling Engineering Co.....	320
Thermograde Valve Co.....	321
Trane Co.....	322
Warren Webster & Co.....	323

STOKERS

Automatic Furnace Co.....	324
Murphy Iron Works.....	325
Westinghouse Electric & Mfg. Co.....	340

STRAINERS, DIRT

Thermograde Valve Co.....	321
Warren Webster & Co.....	323

THERMOSTATS

Fulton Co.....	334-335
Honeywell Heating Specialties Co.....	326
Johnson Service Co.....	257-261
Minneapolis Heat Regulator Co.....	327
Powers Regulator Co.....	328-330

TRADE PUBLICATIONS

Heating & Ventilating Magazine.....	331
-------------------------------------	-----

TRAPS, RADIATOR, RETURN, THERMOSTATIC

American Blower Co.....	267
American District Steam Co.....	299
H. S. B. W.-Cochrane Corp.....	262-263
C. A. Dunham Co.....	300-301
Hoffman Specialty Co.....	304-315
McAlear Mfg. Co.....	317
Monash-Younger Co.....	318
O.-E. Specialty Mfg. Co.....	319
Sarco Co., Inc.....	297
Sterling Engineering Co.....	320
Thermograde Valve Co.....	321
Trane Co.....	293-322
Warren Webster & Co.....	323

UNIT HEATING AND VENTILATING APPARATUS

	PAGE
Herman Nelson Corp.	282-283

VALVES, AIR

American Radiator Co.	274-279
Crane Co.	288-290
Dole Valve Co.	332-333
C. A. Dunham & Co.	300-301
Fulton Co.	334-335
Hoffman Specialty Co.	304-315
Monash-Younger Co.	318
Monitor Bi-Loop Radiator Co.	240-241
Pierce, Butler & Pierce Mfg. Corp.	245-337
Warren Webster & Co.	323

VALVES, AIR LINE

Hoffman Specialty Co.	304-315
-----------------------	---------

VALVES, BACK PRESSURE

Crane Co.	288-290
H. S. B. W.-Cochrane Corp.	262-263
Kieley & Mueller, Inc.	316
Scott Valve Mfg. Co.	339

VALVES, CHECK

Crane Co.	288-290
Donnelly Systems Co.	302

VALVES, DIAPHRAGM

Fulton Co.	334-335
Johnson Service Co.	257-261
Powers Regulator Co.	328-330

VALVES, HOT WATER

Crane Co.	288-290
Hoffman Specialty Co.	304-315
Sandusky Packless Valve Co.	338
Thermograde Valve Co.	321

VALVES, MODULATING

Hoffman Specialty Co.	304-315
Thermograde Valve Co.	321
Warren Webster & Co.	323

VALVES, RADIATOR

American District Steam Co.	299
American Radiator Co.	274-279
Crane Co.	288-290
Detroit Lubricator Co.	336
Dole Valve Co.	332-333
Donnelly Systems Co.	302
Fulton Co.	334-335
Hoffman Specialty Co.	304-315
McAlear Mfg. Co.	317
O-E Specialty Mfg. Co.	319
Pierce, Butler & Pierce Mfg. Corp.	245-337
Sandusky Packless Valve Co.	338
Scott Valve Mfg. Co.	339
Sterling Engineering Co.	320
Warren Webster & Co.	323

VALVES, REDUCING

	PAGE
Crane Co.	288-290
Johnson Service Co.	257-261
Kieley & Mueller, Inc.	316
McAlear Mfg. Co.	317

VALVES, RETURN LINE

Crane Co.	288-290
Hoffman Specialty Co.	304-315

VALVES, SAFETY

Crane Co.	288-290
Scott Valve Mfg. Co.	339

VALVES, THERMOSTATIC

Donnelly Systems Co.	302
C. A. Dunham Co.	300-301
Fulton Co.	334-335
Hoffman Specialty Co.	304-315
O-E Specialty Mfg. Co.	319
Powers Regulator Co.	328-330
Warren Webster & Co.	323

VALVES, VACUUM

Detroit Lubricator Co.	336
Dole Valve Co.	332-333
Donnelly Systems Co.	302
C. A. Dunham Co.	300-301
Fulton Co.	334-335
Hoffman Specialty Co.	304-315
O-E Specialty Mfg. Co.	319
Sandusky Packless Valve Co.	338

VENTILATORS

Hersh Bros. Co.	270-271
L. J. Mueller Furnace Co.	233
B. F. Sturtevant Co.	273

WATER HEATERS

H. S. B. W.-Cochrane Corp.	262-263
Excelso Specialty Works.	303
Kewanee Boiler Co.	234-239
Monitor Bi-Loop Radiator Co.	240-241
Patterson-Kelly Co.	341
Powers Regulator Co.	328-330
Reading Heater & Supply Co.	247
Ross Heater & Mfg. Co.	342-343
Stack Heater Co.	344
Thatcher Furnace Co.	256
Thermal Appliance Co.	345

WATER TREATMENT APPARATUS

Anti-Corrosion Engineering Co.	346-348
H. S. B. W.-Cochrane Corp.	262-263
Patterson-Kelly Co.	341
Permutit Co.	349

Index to Advertisers

	PAGE
American Blower Co.	267
American District Steam Co.	299
American Radiator Co.	274 to 279
Ames Iron Works	221
Anti-Corrosion Engineering Co.	346 to 348
Atmospheric Conditioning Corp.	216-217
The Automatic Furnace Co.	324
The Bahnson Co.	285
Bayley Manufacturing Co.	280
Buffalo Forge Co.	268
Buffalo Steam Pump Co.	291
Carrier Air Conditioning Co. of America	268
Carrier Construction Company	298
Carrier Engineering Corporation	218-219
Celite Products Co.	286
H. S. B. W.-Cochrane Corp.	262-263
Continental Heater Corporation	222-223
Crane Co.	288 to 290
J. F. Davis & Sons Co.	224
Detroit Lubricator Co.	336
Dole Valve Co.	332-333
Donnelly Systems Co.	302
Drying Systems, Inc.	264-265
C. A. Dunham & Co.	300-301
Electric Blower Co.	269
Excelso Specialty Works	303
Fitzgibbons Boiler Co., Inc.	226-227
W. L. Fleischer & Co., Inc.	220
Fowler & Wolfe Mfg. Co.	294
Fulton Co.	334-335
Healy-Ruff Co.	296
Heating & Ventilating Magazine Co.	331
Hersh Bros. Co.	270-271
Hoffman Specialty Co.	304 to 315
Honeywell Heating Specialties Co.	326
Ilg Electric Ventilating Co.	281
International Heater Co.	228 to 232
Johnson Service Co.	257 to 261
Robt. A. Keasbey Co.	287
Kewanee Boiler Company	234 to 239
Keystone Boiler & Foundry Co.	225
Kieley & Mueller, Inc.	316
Massachusetts Blower Co.	272
McAlear Manufacturing Co.	317

	PAGE
Minneapolis Heat Regulator Co.....	327
Minnesota Radiator Co.....	295
Monash-Yunker Co.....	318
Monitor Bi-Loop Radiator Co.....	240-241
L. J. Mueller Furnace Co.....	233
Murphy Iron Works.....	325
Nash Engineering Company.....	292
Herman Nelson Corp.....	282-283
O-E Specialty Manufacturing Co.....	319
Oil City Boiler Works.....	242-243
Wm. H. Page Boiler Co.....	244
The Patterson-Kelly Co.....	341
The Permutit Company.....	349
Pierce, Butler & Pierce Mfg. Corp.....	245-337
Powers Regulator Co.....	328 to 330
Prudential Heater Co.....	246
Reading Heater & Supply Co.....	247
Richardson & Boynton.....	248
Ross Heater & Mfg. Co.....	342-343
Sandusky Packless Valve Co.....	338
Sarco Company, Inc.....	297
Scott Valve Mfg. Co.....	339
H. B. Smith Co.....	350 to 353
Sprague Electric Works.....	266
Stack Heater Co.....	344
Standard Heater Co.....	249
Sterling Engineering Co.....	320
B. F. Sturtevant Co.....	273
Thatcher Furnace Co.....	256
Thermal Appliance Co.....	345
Thermograde Valve Co.....	321
Trane Co.....	293-322
United States Radiator Corp.....	254-255
Warren Webster & Co.....	323
Westinghouse Electric & Mfg. Co.....	340
York Heating & Ventilating Corp.....	284

